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January 1937

TECHNOLOGY REVIEW

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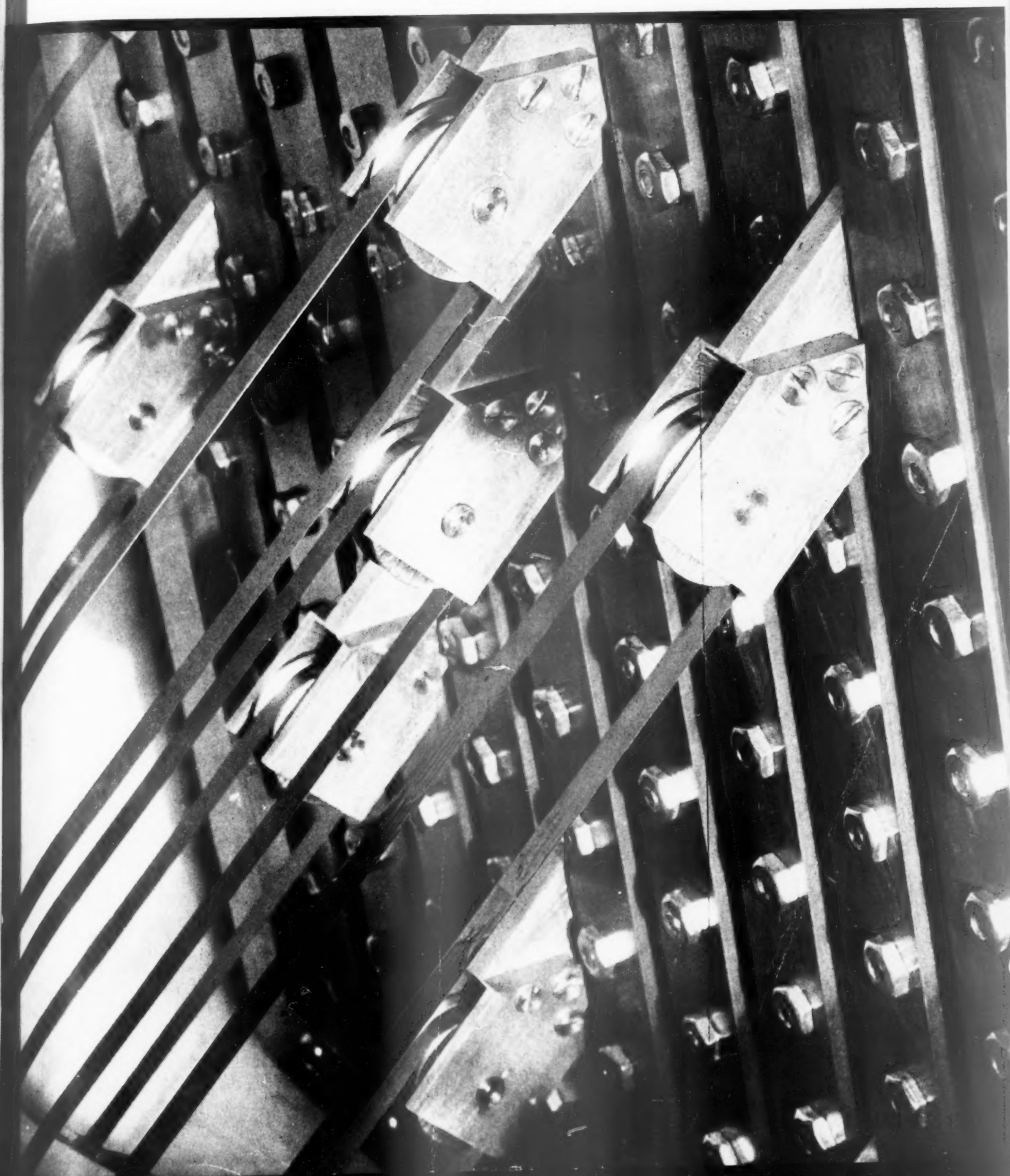

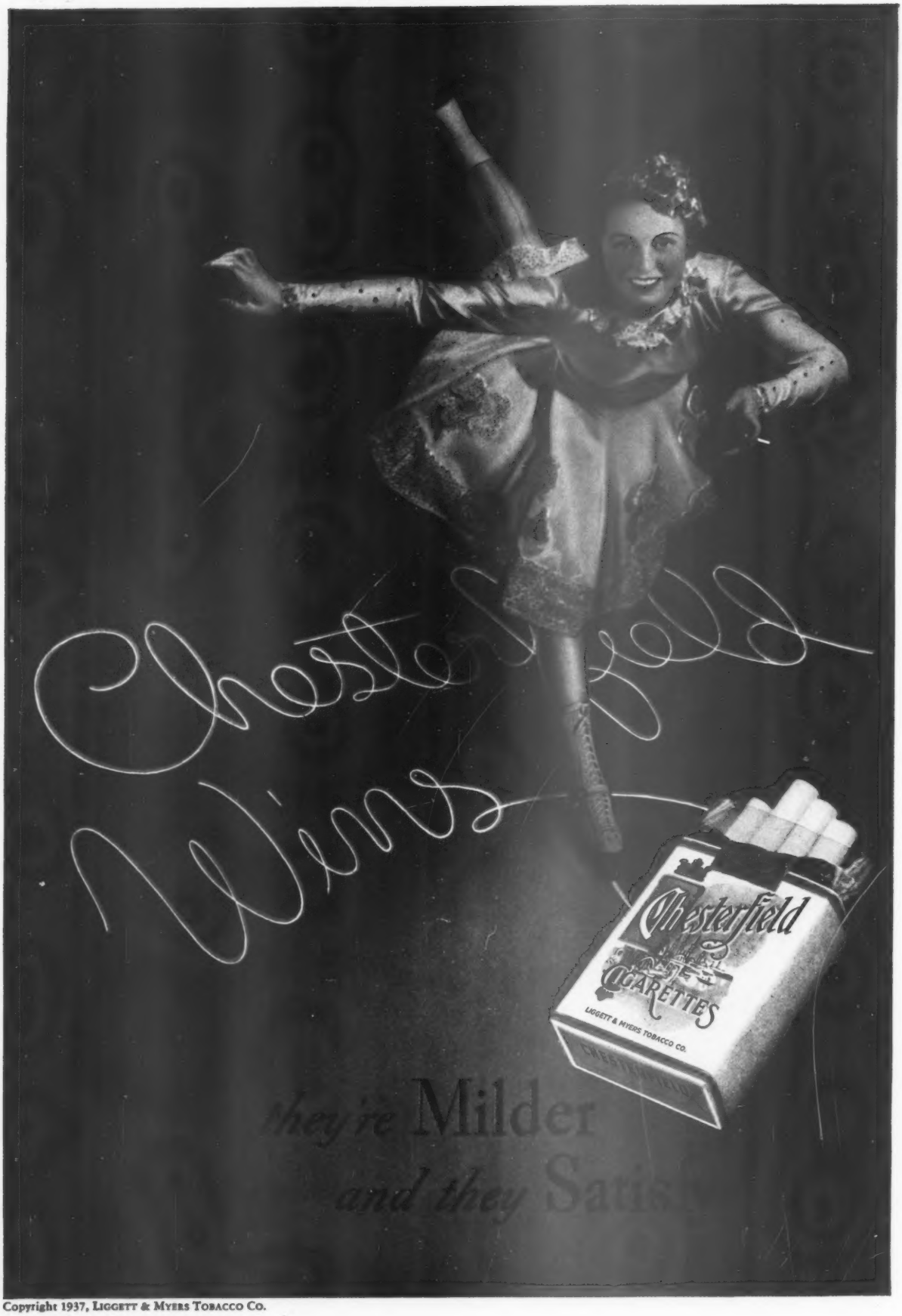

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THE TABULAR VIEW

AS The Review enters 1937 it shows an increase in circulation of six per cent over last year and an increase in advertising of ten per cent. These increases are doubly welcome because they signify The Review's growing usefulness to both readers and advertisers and because they help to ease the burden of a steadily growing volume of editorial material and of mounting production costs. We feel, too, that they reflect growing prosperity on the part of those who participate in the publication of The Review by subscribing and advertising. ¶ The opening of the New Year is an appropriate time to repeat some of our major editorial objectives whether or not we have been able to reach them. The general section of the magazine, to meet our specifications, should be in content unique and in style stimulating and lively. It must present material unobtainable in newspapers and other publications; it must be interpretative rather than purely informational. "People," remarked a character in a recent play, "aren't interested in news any more. They want to know what's happened." ¶ The chief responsibility of Review writers is to interpret, to integrate discrete items of news and information, to orientate the reader, to give him a judicial, organized treatment of facts. "The trouble with much of what is called popularization of knowledge," John Dewey once noted, "is that it is content with diffusion of information, in diluted form, merely as information. It needs to be organized and presented in its bearing upon action. Here is the most significant phase of the obligation incumbent upon the scientifically trained men . . . of our age." The Review seeks to participate in discharging this obligation.

IN March, 1932, page 250, The Review published a statement which it hoped would be definitive on the possibility of ramie fiber becoming an important textile raw material. At that time we said: "One of the most persistently recurring of current fables is that ramie fiber (also known as rhea or china-grass) is on the verge of revolutionizing the textile industry. . . . A careful examination of the facts demonstrates how fabulous most of these contentions really are." Recent reports and queries from our readers sent us again to our chief consultant on textile fibers, Edward R. Schwarz, '23, Associate Professor of Textile Engineering at M.I.T., and in response he writes: "We have no argument against attempts to produce a very satisfactory ramie fabric. We simply point out that very many attempts have been made over a period of time and, as the *Industrial Bulletin* of Arthur D. Little, Inc. (Number 62), points out: 'It is correctly stated that the history of ramie is "made up of a long series of failures and financial loss." ' The fact remains that the data as to the comparative strengths of ramie and other fibers are fragmentary and indefinite. It is also true, because of its fundamental structure, that ramie is inherently brittle. To overcome the brittleness, if eventually this should be possible, will necessitate changes in other properties,

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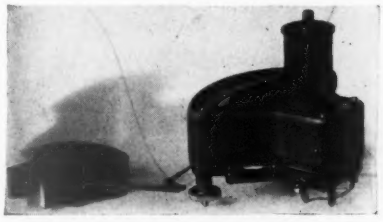

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such as strength and elasticity, which are likely to offset any advantage gained. Service characteristics can be measured only imperfectly by present laboratory methods, but satisfactory service is the final criterion of success and not the ease or cheapness with which the fiber may sometime be produced and spun."

FOR the pictures of Coulee Dam on page 102 and the information about them The Review is indebted to O. G. F. MARKHUS, Assistant Engineer. ¶ The longleaf pine sequence on page 111 came to us from C. E. PATCH, '02, who is an industrial engineer with the Morton C. Tuttle ('96) Company, a Boston firm widely known as a builder of paper mills as well as the designer of many other important engineering structures. Mr. Patch, whose pictures have frequently appeared in The Review, is an inveterate photographer who finds his skill useful both professionally and for documenting his wide travels. After almost every trip he brings to us a portfolio of pictures and generously permits us to take our choice. ¶ FREDERICK H. SHILLITO (page 109) is instructor in medicine and industrial hygiene at Columbia University, and is on the staff of the Presbyterian Hospital. ¶ EVE WITHERS is a *nom de plume* for a person who has had ample opportunity to observe science and its votaries. We do not venture to speculate whether she writes with her tongue in her cheek. ¶ The photograph on the cover was taken by RICHARD E. POPE of the Technology Photographic Service. The many pictures which are published by us bearing the credit line of this organization give ample proof of the competence of its director, Frank H. Conant, and its chief photographer, Mr. Pope.

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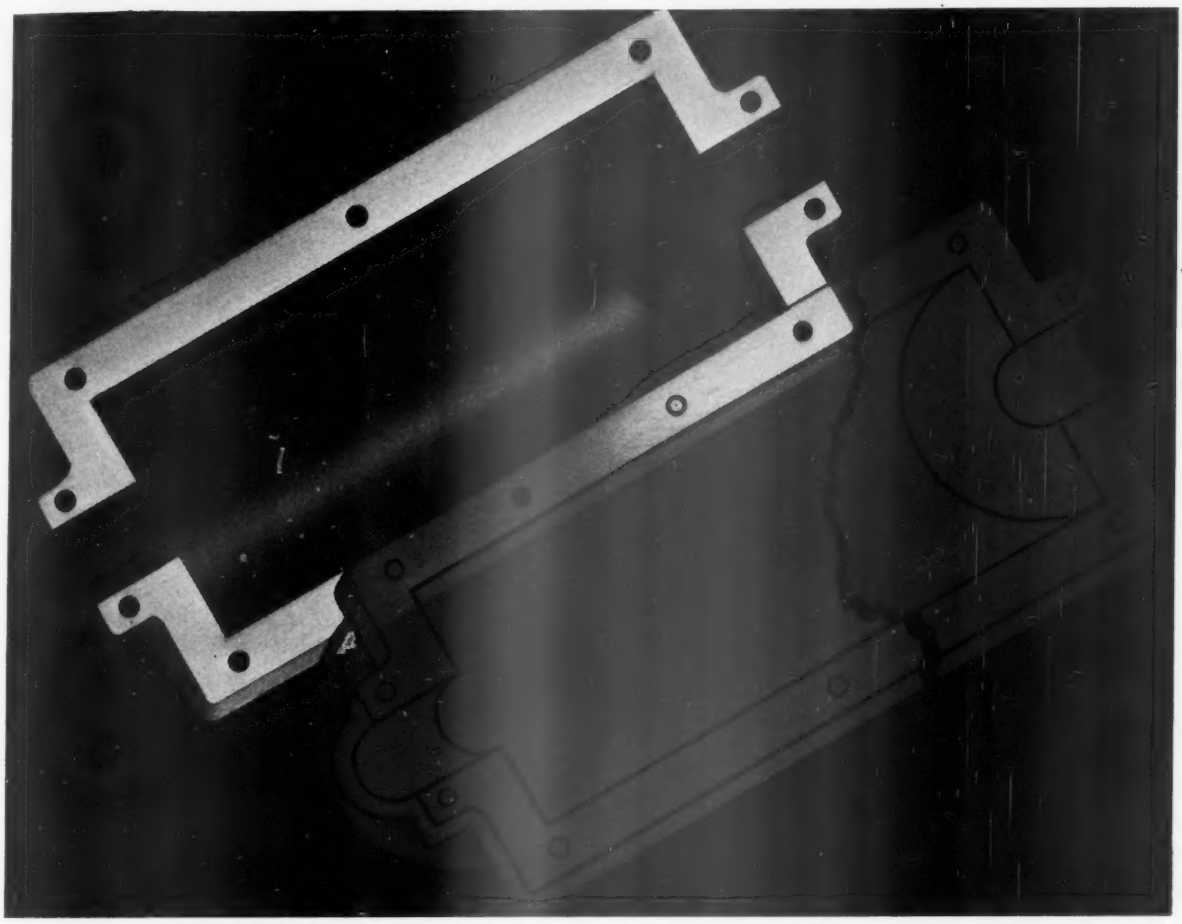

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Coulee's Cofferdam Cribs (*See page 102*)

THE TECHNOLOGY REVIEW

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EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

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Vol. 39, No. 3 January, 1937

The Trend of Affairs

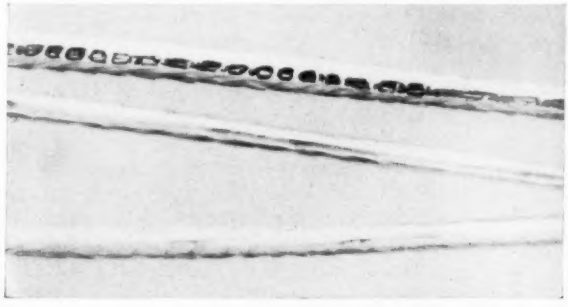
Br'er Rabbit in the Wool Business

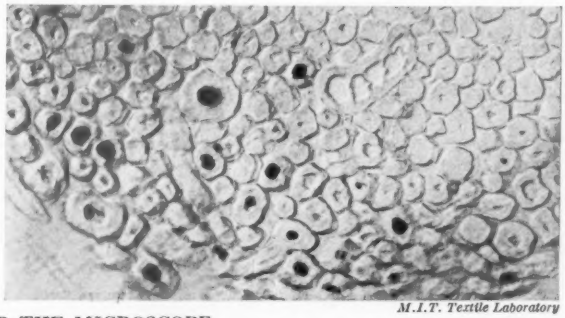
WE heard a reference recently to the "domestic rabbit-wool market" which sent us in search of more information about an industry almost unknown to us and almost everybody else we asked about it. It is general knowledge that the ordinary rabbit supplies fur for felt and skins for fur, but the rabbit-wool industry is a new and fledgling one in this country (the wool began to be imported in noticeable quantities just prior to 1930), despite the fact that French peasant women have been spinning rabbit wool for nearly a century.

One of the surprising facts that we immediately encountered was that already in this country there are such organizations as the New England Rabbit Wool Producers Club and such published literature as "The Angora Wool Farmers' Guide" and "Angora Wool Production." In 1935 there were known imports of rabbit-wool yarn into this country totaling 23,693 pounds. Here was indubitable evidence that Br'er Rabbit had added yarn to his other specialties of fur and felt.

The angora, which is the rabbit from which the so-called wool is obtained, is a native of Asia Minor, but he is now very much at home in England, France, and the United States, particularly in the Pacific Northwest. So silky and fine and soft is the overcoat of this handsome little animal that his fleece has come to be known as *laine de luxe*, or wool of luxury, with prices ranging up to six dollars a pound to prove the aptness of the name. "The fleece," writes William H. Butler in *Textile World*, "compares in fineness to the South American vicuña, is of great tensile strength, very light in weight, pure white in color, apparently warmer than sheep wool, easily dyed, and, even in the long six- or seven-inch fibers, the silky fineness is retained from end to end."

Because of its fineness, however (see illustrations below), angora is very difficult to handle, and cannot be mill-spun without being mixed with wool or silk. In





M.I.T. Textile Laboratory

RABBIT WOOL UNDER THE MICROSCOPE

Left. ***Angora rabbit wool normally contains three different kinds of hairs, typical examples of which are shown. The top strand closely resembles the usual hair formation, the one in the center with its many serrations approximates the structure of sheep wool, while the bottom strand is intermediate in structure between the top two.*** Right. ***Cross section of an angora hair***

R. Lytle Deming, '31

NATURAL ARTIFICIAL

Left. This flash of lightning seemed to belch forth out of a white-hot caldron in the clouds. Note the back-lighting of the clouds, throwing them in silhouette. Right. *In General Electric's Pittsfield laboratory, artificial bolts are discharged as the control and behavior of lightning are studied. Here is shown a ten-million-volt discharge as it arcs and writhes its way between two spheres. Lightning does strike twice, say G. E. engineers. In fact, most fires set by lightning are caused, not by a single spark, but by a series of multiple discharges. Nor is the brilliant flash one observes during a storm a bolt from the sky; it is a union of a cloud streamer with a streamer from the earth*

fact, excessive fineness is the source of the local grower's worst headache; the American angora needs to be crossbred with his coarser-haired cousins if a wool that can be used extensively by our mills is to be grown.

Angora is perhaps most widely used as a substitute for cashmere in the manufacture of fine yarn for knitting, either by hand or machine. Cashmere, the lovely, soft wool that is found beneath the hair of goats in Kashmir, Tibet, and the Himalayas and that has been apotheosized by the shawls bearing its name, is now almost unobtainable in this country; opportunity, therefore, knocks at the hutches that are multiplying, chiefly on the Pacific Coast and vigorously on the Atlantic.

Like the sheep, the angora rabbit may be shorn without injury, although a more even wool is obtained by combing. Angoras in the Pacific Northwest are reported to be clipped three times annually, yielding some four ounces each clip. According to Mr. Butler, who seems to speak with authority, there are rabbits which yield as much as 20 ounces annually. Couple these quantities, however small, with the well-known mass-production habits of the rabbit and they become potentially large. The industry will always be a minor one, of course, even with the substantial expansion that may come, but it is none the less interesting if for no other reason than for its demonstration of how goats in the Himalayas can influence the raising of rabbits in the United States.

Hydrogen for Fuel

BLIND, slow, vulnerable to all manner of weapons, the submarine nevertheless remains one of the most dangerous of war craft. Sufficient evidence of its effectiveness is the fact that when England, in spite of her huge fleet and decisively favorable geographical position, was staring directly into the eyes of famine at the height of the U-boat campaign, not more than 140 German submarines were in action. Any improvement in the submarine's speed or striking power is, therefore, more than a matter of mere academic interest to the millions whose fate may be tied up with its activities.

Germany, deprived of her underwater fleet by the Versailles Treaty, is again building U-boats, and although most of them are as yet small (20 of the 32 she officially admits having are of only 250 tons), many have the speed and carrying capacity of much larger craft, because they are driven by power plants of novel design. Inherent in the standard Diesel-electric drive of the submarine is great weight and space per horse power. It is not so much the electric motor that causes the difficulty as it is the tremendous weight and space needed for the storage batteries, sometimes one-sixth of the total submerged displacement. With batteries is associated also the ever present danger of chlorine poisoning should salt water leak into the containers. The reason for using such an unsatisfactory form of underwater drive is, of course, that it places no drain on the meager air supply enclosed in the hull; any alternative must meet this severe condition. By use of a special internal-combustion engine invented by the German engineer, Rudolf A. Erren, and of high pressure electrolyzers, which are also a German development, the navy of the Nazis has a propulsion plant consisting of a single power unit which appears to meet this difficulty successfully.

Several years ago, Erren perfected a hydrogen engine for utilizing off-peak power from hydroelectric stations. Excess electric current is fed to electrolyzers (in use for many years) which separate water into its component elements — hydrogen and oxygen — at pressures of

3,000 to 4,000 pounds per square inch. The gases, stored in steel cylinders, are then burned as needed — not necessarily together, for the hydrogen can be used with air or mixed with some liquid fuel. When, however, the two gases in their pure form are used, an expanding medium, such as steam from the exhaust, must be introduced into the cylinder, for hydrogen and oxygen, in the proportion two to one, occupy more space than the water vapor that is the result of the explosion. Operating thusly, the engine exhibits a unique characteristic. It is entirely independent of the atmosphere around it, and, if the steam coming from the cylinders is condensed, does not exhaust into the air. Although superficially such an arrangement seems very much like the island where everyone lives by taking in each other's washing, the engine actually is drawing on the energy that had been used to electrolyze the water. Such qualities immediately suggest its use where air is precious, as in deep mines or in submarines. Men being what they are, the military application was the first to gain attention.

From what little can be seen through the veil that is customarily drawn about things military (not so little at that, if the British press be any evidence) the single-engined submarine is driven, while on the surface, by a Diesel engine which can be quickly converted, when submerging, into a hydrogen-oxygen engine. For that purpose the Diesel has, in addition to its usual auxiliaries, electric ignition, a carburetor, special valves, and other apparatus. Probably no change in compression ratio is necessary, since the Erren engine has been operated with ratios of 12 to one and higher, and with better than Diesel efficiency. The gases are stored separately, under high pressure in small steel cylinders which take up about half the space and less than half the weight of the displaced storage batteries. When the craft submerges, the gases are led to the engine at, or slightly above, atmospheric pressure, burned, and the products of combustion (water vapor) condensed and sent back to the electrolyzers.

According to Hector Bywater, naval correspondent of the London *Daily Telegraph*, "there is reason to believe that British naval authorities are fully informed. . . . Its [the engine's] adoption by the British navy may, therefore, be only a question of time."

Ham from Rested Pigs

EFFORTS have been made in this country to show that meat from sedentary steers is less tender than cuts from athletic cattle, and all are familiar with the full body and fine bouquet that marks milk from contented cows. Now comes a report from the Food Investigation Board of Great Britain's Department of Scientific and Industrial Research that pork from rested pigs is more desirable than pork from tired pigs.

It is all a matter, so it seems, of the electrical resistance of pig muscle. Low electrical resistance promotes the penetration of salt during dry-salting. The muscle of pigs overheated before slaughter has, on the average, a higher resistance than that of properly rested pigs. Equally surprising is the conclusion of the Board that hungry pigs yield more bacon: 48 hours' fasting somehow increases the thickness of the flank.

Those who maintain, as did Ellis Parker Butler, that pigs is pigs will also be surprised to know that English curers prefer farm-killed pigs, whose muscle has a very low resistance, to factory-killed pigs, whose muscle has a high resistance. "The difference," remarks the report, "is due to the shaking of farm-killed pigs during transport to the factory. Factory-killed pigs may also be overheated when slaughtered, and the resulting abnormally high electrical resistance cannot be reduced to the required extent, even by shaking."

After these findings hog-killing time on the old place will never be what it once was, we fear, what with the fasting, the resting, and the shaking.

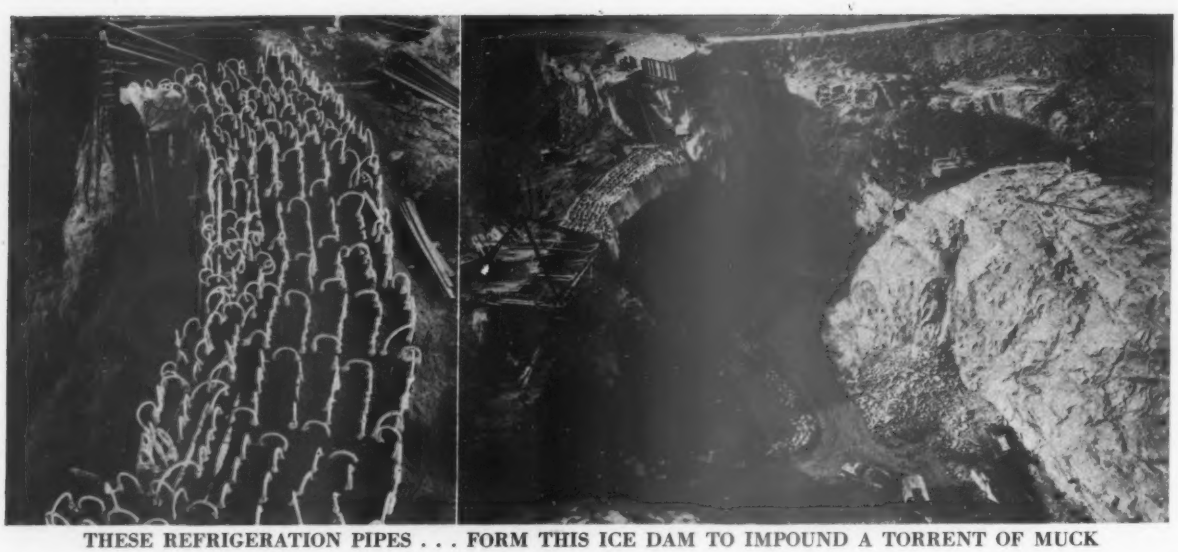
Versatile Virus

VIRUSES — microörganisms so small as to pass through the porcelain filters that hold back ordinary bacteria — are entities of great deadliness and great versatility. They produce a wide range of serious diseases, including the common cold, influenza, yellow fever, and

Barney from Black Star

MIRRORS OF WATER

The Chrysler Building reflected in raindrops. For striking pictures of drops in action see page 104



THESE REFRIGERATION PIPES . . . FORM THIS ICE DAM TO IMPOUND A TORRENT OF MUCK

LARGER THAN BOULDER

Which Means That Grand Coulee Dam Is Man's Most Colossal Engineering Project

On this and the opposite page are a half-dozen views of the great construction job on the Columbia River, which ultimately will irrigate a million acres and generate nearly two million kilowatts. These photographs are mostly side lights — no picture can give a comprehensive idea of 11 million cubic yards of concrete taking form from the world's greatest conveyor system — but each carries a story of ingenuity and achievement on the part of the Reclamation Bureau and the construction company.

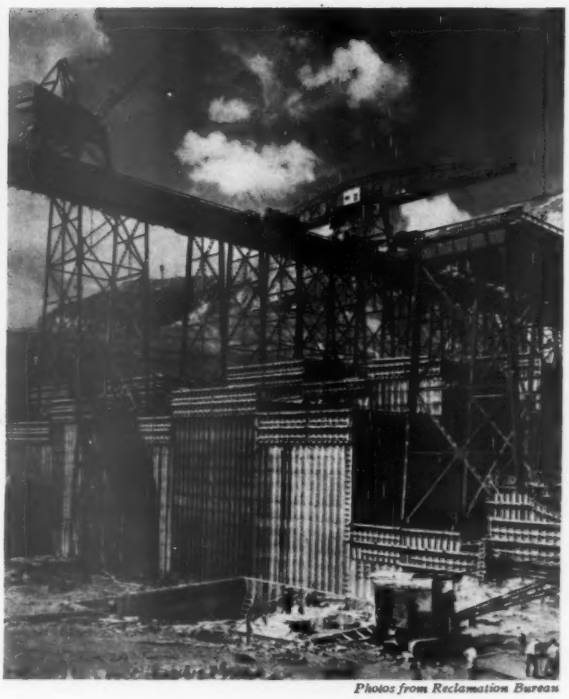
Above. *When construction in the deep gulch shown on the right was threatened by 200,000 cubic yards of loose dirt oozing in, engineers drove refrigeration pipes into the wet muck and with an 80-ton ice plant froze the avalanche to immobility. "This dam has proven very satisfactory," they report, "because it has now been subject to what we consider maximum loads without any particular movement." This artificial ice pack cost $30,000, but saved $100,000 in construction costs.*

Below, left. *A portion of the center tower of the 3,500-foot aggregate conveyor suspension bridge crossing the Columbia from east-side storage to west mix. The 36-inch conveyor belt travels 400 feet a minute, and above it flows cement in an 11-inch pipe 6,200 feet long.*

Below, right. *This concrete mixing plant, one of two, is called the "House of Magic" because of its unusual capacity (it places a cubic yard of concrete in the dam every seven seconds)*

CONVEYOR TOWER

"HOUSE OF MAGIC"



TOTAL LENGTH: 2,300 MILES

. . . Which is 1,720 miles more of cooling pipe than Boulder Dam has embedded in its monoliths. The chemical action of curing concrete generates heat, which in great dams like this would cause destructive internal stresses and would not be dissipated in several hundred years were the dams not cooled by a web of cooling tubes. Eleven pumps will supply cold Columbia River water for Coulee's cooling. **Right.** *The dam is thus poured in a series of blocks with transverse keyways on their sides to interlock with adjacent blocks*

Photos from Reclamation Bureau

infantile paralysis. They may appear at one time an organism, at another, a protein crystal; such a transmutation is performed by the tobacco mosaic virus. They may produce at one time a benign local tumor, at another, a malignant, cancerlike tumor; such an alteration of effect is characteristic of the virus which produces fibroma in rabbits.

Now it appears that they may join in lethal partnership with bacteria, "ganging up" on the luckless human being and often killing him. Dr. Richard E. Shope of the Rockefeller Institute for Medical Research lately told the Yale Medical Society that he had been convinced by experiments that influenza apparently is produced by the concerted activity of a bacterium and a filtrable virus. The conclusion to which he has been brought must, he pointed out, await proof through investigation in future widespread outbreaks of the disease. The experiments upon which he based his remarks date back 18 years to observations which he and Dr. Paul A. Lewis made on a disease of swine, which first appeared at the time of the great influenza outbreak of 1918 and which so closely resembled the human malady that it was known as swine influenza. This disease was found to result from the joint activity of bacterium and virus. Demonstration by English experimenters in 1933 that a virus is concerned in human influenza seemed to justify this theory, then formed, that a germ and a virus were similarly involved in the human disease.

The scientist contending with this versatile foe is in a worse situation than was Hercules in his wrestling match with Achelous, for though Achelous changed his form at will, he was at least visible. The virus is invisible; yet a new device constructed at the International Health Division of the Rockefeller Foundation makes it possible for the first time to isolate viruses in pure concentration. This new separator is expected to permit closer studies of the disease-producing properties of viruses, with, possibly, consequent improvement in methods of combating their deadly effects.

The apparatus is built on the principle of the cream separator familiar to farmers. It is essentially a high-speed centrifuge operating in a very high vacuum, driven by compressed air, with its rotating parts supported by an air bearing. In it, fluids taken from diseased animals and humans, and containing viruses, are whirled at a speed of 30,000 revolutions per minute. Through this rotation there is set up a maximum centrifugal force of 95,000 times gravity.

The apparatus carries 16 celluloid tubes, each of which will hold seven cubic centimeters of fluid. Its effectiveness has been illustrated in the separation and concentration of yellow fever virus, when three hours' centrifuging at 25,000 revolutions per minute caused most of the viruses to be not merely sedimented out of the solution, but so firmly packed to the bottom of the tubes that the fluid could be poured off and the sediment resuspended in fresh fluid without notable loss of activity.

Another defense against virus activity recently reported by Dr. W. Lloyd Aycock of the Harvard Medical School is an experimental technique which may lead to the determining of a means for detecting persons susceptible to infantile paralysis. The relation between internal glands and mucous membranes is basis for the technique; the membranes are known to play an important part in the infection; internal glands, medical men are coming more and more to believe, play an important part in defense against the disease. Diminishing the secretion of one of the endocrine glands which controls membrane growth in monkeys, then treating half the

monkeys with estrin to restore the weakened linings, following this by artificially infecting all the monkeys with infantile paralysis, the investigators found that the subjects with restored membranes did not catch the disease so readily as did the unprotected, and that their survival rate was better. The gland controlling the growth of the mucous membrane, consequently, is considered to have direct relation to resistance to the disease.

The Moon and Zostera

WHEN Galileo was told that Johannes Kepler had advanced the theory that the moon influenced the motion of the tides, he expressed regret that so able a man had seen fit to reintroduce the occult into science. The same suspicious attitude toward our nearest heavenly neighbor still persists among scientists, and the research worker who mentions the moon as affecting the antics of anything but lovers and spiritualists endangers his reputation. Nevertheless, Neil E. Stevens of the University of Illinois has pointed to some pertinent, if not clinching evidence that the moon may supply the solution to a current biological puzzle.

Along the tidal flats and gently sloping beaches that border the two great oceans of the north temperate zone there grows (in many areas, grew) a flowering plant with long, narrow leaves which is officially *Zostera marina*, but is popularly known as eelgrass. On it depend, directly or in devious ways, such varied creatures as wild ducks, Eskimos, fishes, and farmers.

About five years ago, it slowly began to dawn on observers that eelgrass beds were rapidly disappearing. Where once there were acres of the plant, there were in 1932 only isolated patches, and those mainly near the mouths of rivers where the salt water was more than usually dilute. Letters from European scientists brought the information that the same phenomenon was occurring there also. Beds on the Pacific Coast, however, were not affected.

No sudden disturbance in the numbers of any organism can be lightly dismissed by man, for rugged individualism is a political, not a natural, state. Ducks and doctors are alike involved in nature's equilibrium. The rootstocks of eelgrass, for example, are the chief winter food of brant and Canadian geese, while black ducks and fishes nibble at its seeds, and, continuing the cycle, Eskimos depend for a large portion of their diet on migratory birds. Housewives, too, are affected, for the abundance of food fish is influenced by feeding conditions near shore. When dried, eelgrass leaves are durable, elastic, vermin proof, and, because of air cells in their structure, of considerable insulating value. Canadian farmers, therefore, use the leaves to bank the foundations of their buildings in cold weather, and there are firms which harvest the plant for house insulation.

A biological puzzle of such great extent and importance calls imperiously for an explanation. Many have been forthcoming, generally distinguished by the ease with which they are eliminated, but from intensive research into this plant's life and ecology and from the integration of some widely diversified data have come much interesting information. The disappearance of eelgrass is not an isolated event, but happened at the same time as an unprecedented northward extension of bacterial wilt in corn that appeared to be connected with weather conditions. Furthermore, a search through old records disclosed two other periods of eelgrass scarcity, one including the year 1894 and the other, 1913. Another

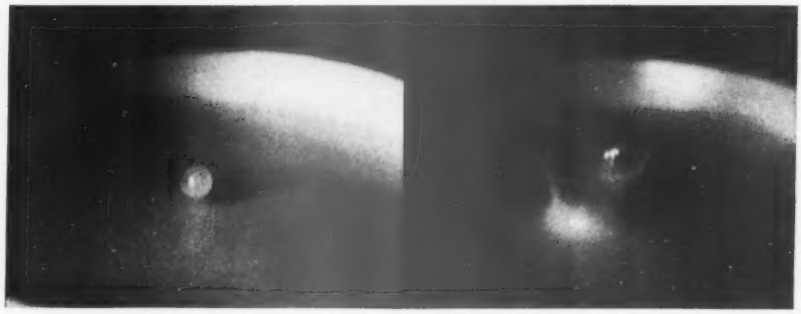
BIRTH OF A BUBBLE

A Drama of Surface Tension in Ten Scenes

When raindrops splash into a pool of water they frequently form bubbles that float on the surface for a brief span. Here this familiar phenomenon — the parturition of a bubble — is captured in detail by the high-speed camera in a sequence of ten pictures. Instead of water, milk is used because the photographic emulsion shows it more clearly.

In picture 1 the drop is plummeting downward toward the surface of the pool of milk. Picture 2 catches the delicate crownlike formation of the splash, and pictures 3, 4, and 5 show the forces of surface tension, like the strings of a tobacco bag, acting to close the crown at the top and to entrap air within. In picture 6 comes the climax as the bubble, with an eruption of droplets, closes tight; in 7, 8, and 9 may be seen its contortions as it overcomes, by a narrow margin, the disruptive forces set up by the splash, and, finally, in 10 the shimmering bubble stands full-bodied and complete

Photographs by Harold E. Edgerton, '27, et al.



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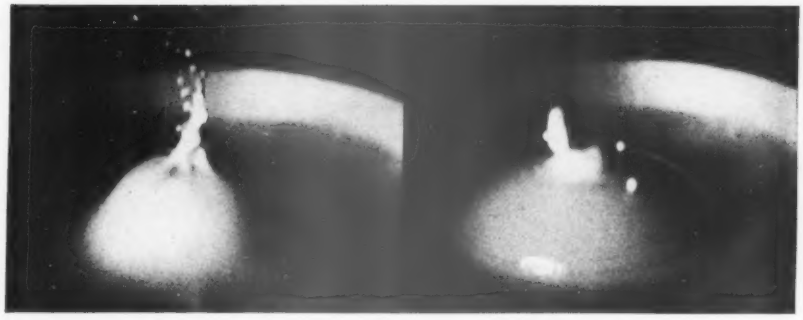

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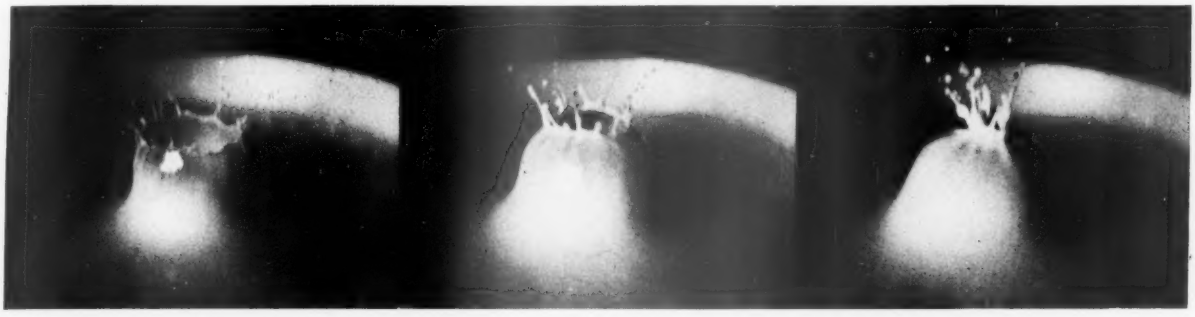
investigator found that optimum conditions require a very narrow temperature range and that any temperature exceeding 68 degrees F. is definitely unfavorable to the plant's growth. Evidence of a slight increase in temperature of North Atlantic waters at the height of the epidemic, if we may call it that, is the collection of tropical fishes and plankton forms in areas where they were previously rare or unknown. It is also known that poor fishing seasons, which, significantly, occur at regular intervals, are associated with an extensive invasion of the Banks by waters of tropical origin. Allowing for the effect of improvements in fishing equipment, the years of minimum yields from the Newfoundland grounds include 1893, 1904–1905, 1913, 1921, and 1929.



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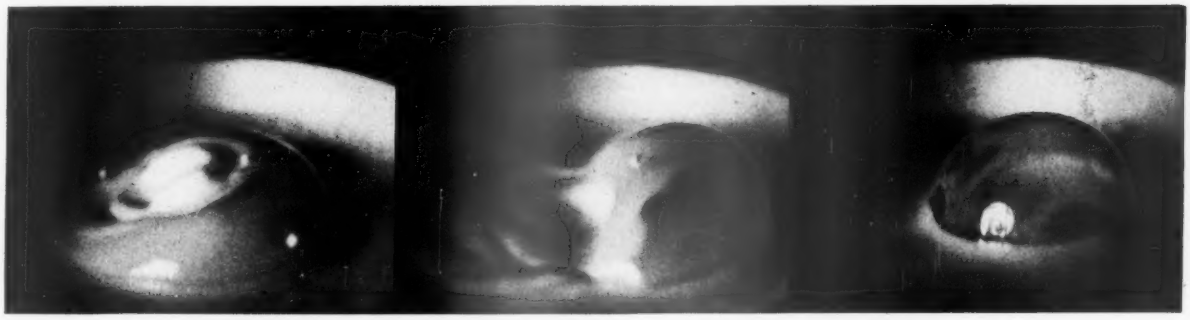

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Each alternate minimum coincides fairly closely with a period of eelgrass scarcity. But what part does the moon play in all these varied proceedings?

Astronomers, like stockbrokers, have a fondness for graphs. One, looking like a slightly intoxicated sine wave with peaks about 18½ years apart, shows in the dogmatic manner of graphs that the moon reached its maximum northerly declination in 1895, 1913, and 1932. The conclusion, plausible if not probable, is that the moon, in its cyclic meanderings over the heavens, shifts major ocean currents so that tropical waters invade areas normally covered by continental waters of polar origin. The eelgrass in such areas, dependent for maximum resistance on closely adjusted environmental conditions, is weakened by subtle but dangerous changes in that complicated, little understood conglomeration of solutes that is sea water, and parasites always present in or about the plant become dominant. A condition of eelgrass scarcity develops and continues until such time as a resistant strain evolves or conditions change.

The proof of the pudding, after all, is in the eating, and the mark of a successful theory is accurate prediction. If (is this mixing a metaphor?) *Zostera's* unlucky star is the moon, the next period of eelgrass scarcity seems due in 1949 or 1950.

Stifling the Imp of Corrosion

THE little red demon who represents corrosion in the advertisements, like so many other demons who nowadays work for us or work against us, is electrical in his innermost character. The name by which he is known, his familiar name and the one to which he answers readily enough, is chemical, but his family, nevertheless, is electrical. Indeed the cause of corrosion appeared in the early experiments of Galvani and Volta which stood at the very beginning of the modern development of electrical knowledge and theory.

When dissimilar conductors are brought into contact, a difference of electrical potential is set up between them. When a metal is brought into contact with water, a difference of potential is set up, and, if the metal is one which like zinc, iron, or aluminum is more electropositive than hydrogen, then chemical action commences. From the time of the earliest experiments on the subject there has been discussion whether the difference of potential arises from the mere contact of the dissimilar substances or from the chemical action, or tendency toward chemical action, between them. Scientists have not come to an entire agreement, but all agree that the difference of potential is the cause of the corrosion which results.

When iron is in contact with water it becomes negatively charged. The positively charged hydrogen ions which are present in water in small amount and in acid

solutions in much larger amount are attracted to the negatively charged metal; they give up their charges, hydrogen escapes in the form of gas, and a corresponding amount of the iron goes into solution and is corroded away. Any means which reduces the number of hydrogen ions in the solution reduces the amount of the corrosion. We circumvent nature by conforming to her rules. Alkaline solutions contain fewer hydrogen ions than acid or neutral ones. They produce less corrosion; this is the evident reason for the use of triethanolamine and similar substances as anticorrosives. But there are other substances, operating on a different principle, which reduce corrosion and under favorable circumstances almost totally prevent it in the presence, even, of strongly acid solutions. They are called inhibitors. Small amounts of them added to acid solutions have no material effect in reducing the acidity or hydrogen ion concentration, but they nevertheless protect the metal against the acid to a remarkable degree.

Lewis P. Tabor, '22

Triangles point skyward on the mast of a vessel

Inhibitors yield positively charged ions which are apparently attracted to the negatively charged surface of the metal. There they form a coating which, to a greater or less extent, prevents the hydrogen ions of the liquid from coming into contact with the metal. The hydrogen ions are not discharged, hydrogen gas is not given off, and the metal is not dissolved. This realistic and mechanical explanation of an effect that seems almost magical has been confirmed by the recently reported experiments of Mann, Lauer, and Hultin of the University of Minnesota.

To determine the rate of uninhibited corrosion these investigators exposed samples of mild steel to normal sulfuric acid solution at 25 degrees for 46 hours and calculated the loss in weight of the metal in grams per square centimeter per hour. They then tried the effect of adding small amounts of ammonia, of aniline, and of other ammonia derivatives, and calculated their per-cent effectiveness in reducing the amount of the corrosion. The best inhibitors were 90% effective, some of them nearly 100%, when as little as 0.25 gram of nitrogen in the form of the inhibitor was added to 100 cubic centimeters of the acid solution. This is only about one-sixth as much of the inhibitor as is needed completely to combine with the acid.

The ammonia molecule consists of three hydrogen atoms attached to a single nitrogen atom. The positively charged ammonium ion consists of a single nitrogen and four hydrogens. Aniline, which differs from ammonia in having a bulky phenyl group substituted in place of one of the hydrogens, is a better inhibitor than ammonia, evidently because the bulkier phenyl group gives the ion more covering power. If a second hydrogen of the ammonia molecule is replaced by another group, say a methyl group, then the substance is more effective; if a third hydrogen, then better yet. If the methyl group is substituted in the phenyl, two of the original hydrogens of the ammonia being left, then it increases the size of the group in which it is substituted and gives it greater covering power and inhibitor action. But the same methyl group is more effective if it is attached directly to the nitrogen where it is nearer to the positive charge of the ion and in a better position to cover the metal. Diphenylhydrazine, whose molecule is virtually two molecules of aniline linked together through the nitrogen atoms, has more than twice the inhibitor action of aniline, presumably because the two phenyl groups in the same molecule repel one another, flatten out, and effectively increase the area of the molecule. In short, the results demonstrate fully that the shape of the ion is something which may be known and reckoned upon.

Organic chemists can build up their molecules with as much certainty and precision as if they were building toy houses out of wooden blocks. They can choose among their molecules those which ought, according to the best theories of corrosion, to exert the greatest inhibitor action. When they try them out, they find that the molecules behave in ways of their own, in ways, moreover, which give new insight into the stresses and strains which exist within them, into the mechanical effects of the affinities by which they are held together.

Mass and Bulk

THE massive mind may not necessarily be an inhabitant of the bulky brain; most recent developments bearing on this psychological truism were recently made public by way of Dr. Ales Hrdlicka, curator of physical anthropology of the Smithsonian Institution. In excavations last summer Dr. Hrdlicka found the skull of an Aleutian Islander. Its brain capacity is 2,005 cubic centimeters — only 25 cubic centimeters less than that of the Russian author, Turgenieff, whose brain was the bulkiest known in man's history. The Russian, whose brain weighed 74 ounces — about an ounce more than that of the Aleut — would appear to give the lie to the psychologist's generalization but for the fact that an average male brain of 53 ounces, or about 1,450 cubic centimeters, sufficed an obscure Corsican soldier in his rise to become emperor of the French as Napoleon, and the fact that a brain weighing only 45.3 ounces produced the "barbaric yawp" that made Walt Whitman one of the two or three most widely read and influential American writers.

The unsung Aleut of the mighty brain bowl left behind him a perfectly normal skull, according to Dr. Hrdlicka, who reported it as showing no signs of pathological disturbance such as gigantism or water on the brain, which might have affected its size. The owner probably had a brain normal in all but bulk. The Smithsonian Institution's announcement declared it reasonable to suppose, however, that the Aleut was a man of exceptional intelligence, and that, if he had any chance at all, he made his mark in the world.

A device likewise came to public ken last fall, which one day may be of indirect assistance in determining why the Eskimo, probably kin of the Aleut, with a brain bigger than the average, has not done so much with it as the Hindu, whose brain in bulk is below the average. This device constructed of glass, rubber, and metal, to enable physicians to study the functions of the brain by means of a dummy, was perfected by Drs. Temple Fay and W. B. Chamberlain of the medical school of Temple University. By means of it, pressure changes occurring inside the arteries and veins of the normal brain can be demonstrated, as can those which take place in the presence of tumors and head injuries. Artificial coma also may be produced and studied, and the way the brain is bathed by the cerebrospinal fluid can be shown.

By the use of such mechanical aids, with studies of electrical brain waves, the cause for discrepancies between might of mind and bulk of brain is sought.

Heavy Water's Heavy Industry

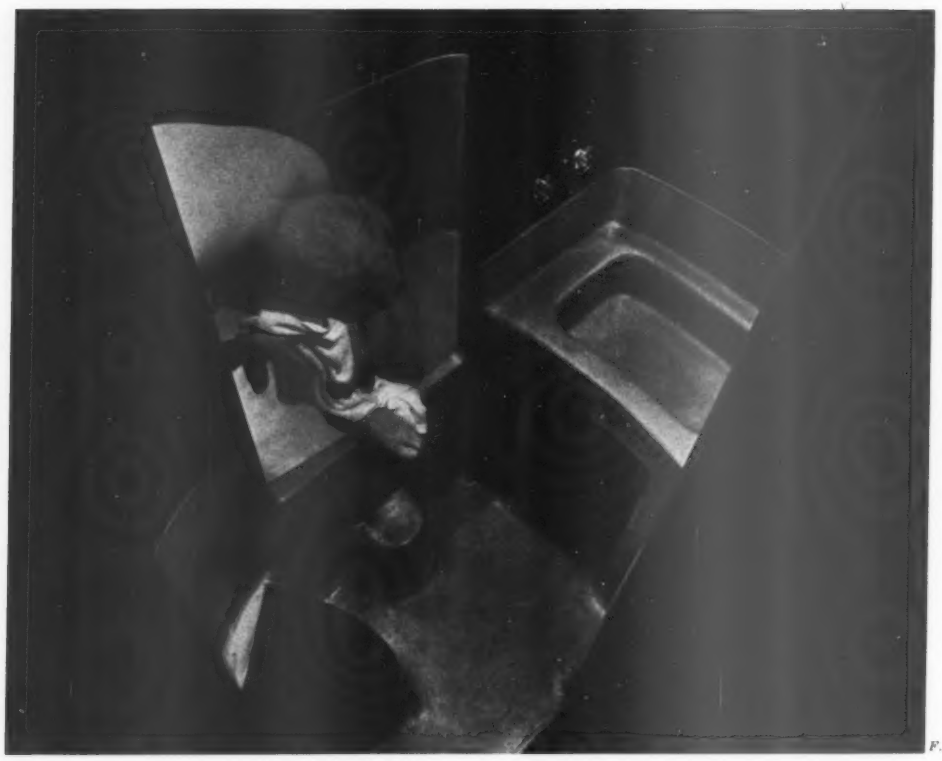
THE benefit of a fundamental scientific discovery is twofold. Besides opening the way to further discoveries it suggests new types of experiments; these tax the capacity of existing experimental methods, with the result that old processes are improved to new usefulness. The direct importance of the discovery of heavy hydrogen and heavy water by Professor H. C. Urey is familiar and needs no emphasis, but the indirect benefits are proving to be less obvious.

As the work on heavy water progressed it became evident that the central problem of chemical isotopic research was the preparation of water rich in heavy oxygen. The separation by electrolysis, so successful in the case of hydrogen, fails in this case. The various theories of matter have been ransacked for processes which might effect a useful amount of separation, and two offering some promise — fractional distillation and fractional diffusion — have been found. Professor Urey prefers the first alternative and has devoted himself to the improvement of apparatus for distillation. The demands of the petroleum industry have led to great improvements along this line during the past 10 years, but no existing apparatus offered any hope of isolating even one gram of heavy oxygen with any reasonable expenditure of time and power. Acting on a suggestion of Dr. Pegram, Professor Urey has developed a new type of still which is much more effective than any previously known. Whether this still will solve the oxygen problem or not it seems certain to make a lasting impression on industrial distilling methods, and it is a beautiful example of the remote and unexpected practical uses that frequently derive from pure science.

Although fractional distillation by Professor Urey's method appears to be the most promising method of separating isotopes, other possibilities have been studied. One of the most interesting of these has been developed at the *Technische Hochschule* in Berlin by Professor G. Hertz, who has been interested for some years in industrial applications of the separation of gases by fractional diffusion.

Breath-taking majesty of line and curve as the 4,200-foot span of the Golden Gate Bridge moves toward completion. The tower shafts of this bridge are by far the largest structural steel members ever assembled

School from Nesmith



F. S. Lincoln, '22

PREFABRICATED BATHROOM UNIT

Buckminster Fuller of Dymaxion fame has designed for Phelps Dodge this mass-production bathroom in which the three "primary bathroom fixtures" are stamped from metal and are integral parts of the floor and walls of the lower third of the room "or what might be called the splash sector." Other features: sliding doors, atmospheric control, finished weight of approximately 150 pounds (compared to 1,000 pounds or more for old-style bathrooms), indirect light in bottom of bathing chamber, electric heating system, Venetian blind on door to bathing chamber

The basic phenomena were worked out by Graham in 1846, but when simply applied the unit process leads to separations so small as to be useless. Professor Hertz designed and built an apparatus wherein the gas mixture to be separated is forced through a complicated network of glass and clay tubes in such a way that the unit process is automatically repeated many thousands of times, until a steady state is reached in which the heavier portions of the mixture are concentrated in one end of the network. His final apparatus contained 50 mercury diffusion pumps and filled a large room. He was able to separate completely the isotopes of neon, but the apparatus failed when applied to water vapor. Repeated passage through the hot mercury vapor in the pumps partly decomposed the water to oxygen and hydrogen, and the oxygen gas flooded the output end of the apparatus. Attempts are being made at the Institute to apply the Hertz principle to a more practical apparatus, and some promising results have already been obtained.

During the first few months following the discovery of heavy hydrogen and heavy water, the amounts available for study were small, and a method of analyzing for heavy isotopes was needed. The specific gravity of water is sensitive to the presence of heavy isotopes, and it can be measured readily and accurately by any of a number of methods which have been known and used for many years. However, the combination of new requirements — small sample and high precision — was at the limit of the possibilities of any of them. At the Kaiser Wilhelm Institute for Physical Chemistry in Berlin-Dahlem, a method was devised for measuring the specific gravity of samples of water as small as five milligrams to an accuracy of one part in 10 thousand. The sample was contained in a tiny glass pycnometer sealed to a closed, thin-walled bulb smaller than a match head. The weight of the whole was adjusted so that when filled with ordinary water and placed beneath the surface of water cooled to the temperature of melting ice, at a surface pressure of one-half atmosphere, it remained suspended with no tendency either to rise or sink. When filled with slightly heavy water and immersed under the same conditions it would sink but could be restored to equilibrium by decreasing the pressure on the water, so expanding the thin-walled bulb and increasing its buoyancy. From the increase in pressure required, the specific gravity could be calculated.

When large samples of water became available and greater precision was required, a variation of this method was developed at the Institute. Water is generally regarded as an incompressible fluid, but it is easy to demonstrate that an increase in pressure of one atmosphere causes a decrease in volume of about 40 parts per million. Thick-walled glass floats are much less compressible. Such floats were adjusted to remain suspended when totally immersed in water at the temperature of melting ice and one-half atmosphere pressure. When immersed in slightly heavy water under the same conditions, the floats rose and equilibrium was restored by changing the pressure until the heavy water had the same density as ordinary water. These floats were extraordinarily sensitive: A pressure change of one two-thousandth of an atmosphere was sufficient to produce a readily observable effect on them. The precision obtained was one part in 10 million on the specific gravity.

Health Hazards in Industry

The Campaign Against Occupational Diseases

By Frederick H. Shillito

WITHIN the factory walls of modern industry can be found every imaginable climate and environment that Nature has in her repertory of extremes — plus a few others that in their synthetic subtlety go far beyond natural discomforts. In steel mills, blast furnaces radiate heat much greater than the hottest desert wind; around paper machines there may be a wet, steamy atmosphere as thick as the proverbial London pea-soup fog and as dripping as the jungle; photographic and light-fast operations place workmen in darkness comparable to the darkest night; refrigerated rooms surround others with Arctic coldness; some processes, particularly in mining and grinding, stir up miniature dust storms that for appearance might have arisen from the mid-West dust bowl; over bubbling vats may hover atmospheres containing chemicals more insidious than volcanic gases in nature.

These potentially harmful industrial environments are multiplying as manufacturing, in response to scientific discovery, becomes technically more complex and synthetic in its processes. Fortunately, however, as industrial hazards increase, we find intelligent industry invoking science again — this time to circumvent the dangers of these unnatural environments. Physicians, with special interest in industrial health problems, are working coöperatively with engineers to point the way toward safer working conditions.

Mortality statistics strikingly emphasize the need for an expert approach to industrial hazards. A study by Louis I. Dublin of the Metropolitan Life Insurance Company of the life expectancies of 3,250,000 insured industrial workers has shown that men between the ages of 20 and 40 years who are engaged in industry have an expectancy of life shorter by about six or seven years than that of the average individual. Workers in older age groups likewise show shorter life expectancy, but to a less marked degree, as might be expected. Dr. Dublin has reported two studies of this nature and it is encouraging that the more recent study shows an improvement in the industrial worker's life expectancy.

The United States Public Health Service has had the opportunity of studying, since 1917, the incidence of disease in 160,000 living workers. This is in contrast with Dr. Dublin's figures, which deal only with death statistics. All of the ordinary diseases necessitating absence from work for a week or more are reported to the United States Public Health Service. According to Dr. R. R. Sayers of this department, the study is already showing results in that certain industries can be shown to have unusually high incidence of respiratory diseases. Groups of employees exposed to high temperatures and drafty positions suffer a high pneumonia rate. Respiratory diseases are three times as great in granite cutting as in general manufacturing and the rate of pulmonary tuberculosis is about 40 times as great. The disclosure of such facts makes imperative the type of industrial survey that will lead to improvement in working conditions.

The technique of the industrial physician in aiding industry's campaign to raise the life expectancy of workers to the normal figure rests on a thorough knowledge of the human body and on a thoroughgoing analysis of a given industrial environment, in so far as it is different from the natural, outside weather. Temperature, humidity, movement, quality, and pressure of the air breathed by the worker must be determined; types and degrees of radiant energy present should be known; and the chemical and physical characteristics of all materials handled, elaborated. With this information in hand, a physiological study is then made which consists, in simple terms, of the determination, by medical physical examination and laboratory investigation, of the effects of the particular environment on the normal man.

As the physician well knows, man would suffer far more if it were not for his very great capacity in protecting himself against harmful environments. This activity, on the most part wholly unconscious, probably stands second only to reproduction of the species in importance as a vital function of life. The physiology of this protection is exceedingly complex, but let me, despite the danger of oversimplification, describe a few of the processes that are particularly important in resisting the hazards of industrial environment.

First of all, the skin, which forms a supple, pliant covering of the body, is well adapted to resist the rigors of industrial environment. The organs of the interior of the body are vulnerable to any drying-out process. When any considerable amount of the skin is destroyed, as in burns, the evaporation of body fluids proceeds rapidly, the blood is concentrated, and its viscosity increases to a point where it impedes its own flow. Such a condition will prove rapidly fatal. The skin, without being permeable, maintains body fluids without dangerous loss by evaporation. Only enough fluid is evaporated from the skin to aid in maintaining body temperature at its constant level.

This function of the skin in helping to prevent changes in body temperature is important. The vital tissues endure changes in temperature very poorly: A rise of 10 degrees F. is practically incompatible with life. The human heat-regulating mechanism keeps the body temperature constant within a few degrees. In the absence of disease, body temperature practically never rises more than two or three degrees F.

The problem is to get rid of heat generated within the body due to the physiochemical processes of life. When a man is quiet, the body generates about 400 British thermal units per hour. This amount of heat, not very

great, is dissipated easily in a number of ways, such as by evaporation of body moisture into air breathed, by direct radiation of heat from the body surface, by convection, by conduction, and by invisible evaporation of skin moisture. These means of losing heat are more or less constant and are about sufficient to dissipate all of the excess body heat at ordinary room temperatures.

Matters are quite different, however, when the body generates excessive heat by muscular exertion or experiences difficulty in heat dissipation because of high room temperatures, as near blast furnaces. Under such circumstances the usefulness of the skin as a protection against the environment is manifest as it pours literally quarts of water over the surface of the body in the perspiration. The evaporation of this water cools the body. This simple process is vitally important. It is the last line of defense against disastrous rises of body temperature.

Another phase of man's physiology which is useful in protecting him against harmful industrial environments is the respiratory tract. In the first place, the sense of smell warns when air differs qualitatively from normal outside air. Odors can be detected when only the minutest trace of materials is present in air. Unfortunately, fatigue of the olfactory sense develops rapidly and workmen become accustomed to a long continued odor. Furthermore, high concentrations of materials may be quite odorless. The investigator, however, can often trust his sense of smell in leading him to correct assumptions as to the presence or absence of odorous contaminants in the workroom. Related to the sense of smell are a series of reflexes which often do protect workmen against noxious fumes. These consist of uncontrollable coughing, sneezing, lacrimation, and discomfort. These reflexes are set up when irritants such as acids are present in the air. They are the forces that drive the uninitiated person away from dilute concentrations of ammonia gas or nitric oxide fumes. This mechanism is not entirely trustworthy; often it does not operate in high concentrations of chemicals. For instance, nitric oxide fumes can sometimes be breathed deeply into the lungs without the slightest sensory discomfort. The lungs are thereby injured and serious effects, even fatal, can follow.

Air passing through the nose and bronchial passages must be cooled or warmed to body temperature. It has to be humidified and cleaned. These things are done in the upper air passages in the nose and throat. At the nostrils of the nose coarse hairs trap large floating particles, such as lint or scaly materials. Inside the nose the air is brought into contact with moist, sticky surfaces, which cause all but the finest particles to adhere. This is fly-paper action. Going down through the bronchial tree the air is forced through smaller and smaller passages lined with moist, sticky walls and exceedingly fine hairs, called cilia. An undulating movement of these hairs keeps pushing particles extracted from the air back toward the throat, where they can be coughed up. Eventually the air passes through passages about one-tenth millimeter in diameter and enters the final respiratory sac. The filtering and purifying mechanism is finished. At this point, absorption takes place and the air must be clean and pure.

IN considering the health hazards in industry, therefore, it is seen that all effects necessarily fall into one of two groups: (1) effects upon the protective mechanism of the body, such as the skin, mouth structures, membranes of the respiratory tract, and so on; (2) more widespread effects due to absorption beyond the sphere of the protective mechanism.

In the first group (physical changes in tissues comprising part of the protective mechanism) probably the simplest illustration is a burn caused by a small drop of spattered molten metal. The only tissue affected is the skin, which has suffered injury while serving its function as a protective coat over the underlying tissues. The body as a whole has not been affected, except by the discomfort of pain and the possibility of secondary infection. Related to this type of injury are a host of dermatoses (affections of the skin) caused by contact with materials such as dyes, acids, solvents, oils, and so on.

This problem of the occurrence of skin diseases in industry is a very serious one. Workers particularly well trained and well adapted to a certain operation may be forced to leave it because of a troublesome dermatitis caused by some substance contacted in the work. The lesions often become secondarily infected and are difficult to treat medically. It is also practically impossible to determine the material causing the trouble by examining the skin lesion. The dermatitis may be caused by any one of many different substances and yet have no characteristic appearance to distinguish the cause.

Drs. J. J. Eller of New York and Louis Schwartz of the United States Public Health Service have reported that 65% of occupational diseases are dermatoses, that 20,000 cases in the United States are forced to lose working days each year. Furthermore, it is estimated that one per cent of all employees have occupational skin dermatoses. Many of these conditions are quite trifling, but can be annoying to the individual affected. Furthermore, the break in the skin is a potential site of a serious infection at any time. It is obvious that there must be a high cost to industry — direct or indirect — associated with the fact that the human skin is so vulnerable to external agents.

The membranes of the nose, which play a protective rôle against noxious gases and fumes, are themselves damaged by certain of these materials — particularly by irritant substances which settle out of air rapidly, such as chromic acid spray or certain oxides of arsenic. Such substances actually destroy the structures of the nose, giving rise to perforation of the nasal septum and to chronic nose conditions. Other substances, such as cement dust, may pass through the nose and not be trapped until the larynx or upper trachea are reached. At these points irritation of tissues will result in hoarseness of the voice and in cough.

The question often comes up as to the possible harm from industrial dusts composed of large flaky or fluffy materials. Assuming that these materials are perfectly inert, it is still true that the nose has to strain all of them from the air. This process will plug the nasal passages and may result in upper respiratory infections if the materials are present in large amounts. If such a dust cannot be eliminated, the (*Continued on page 122*)

NURSERY: AGED EIGHT MONTHS

Seedlings of long-leaf yellow pine growing in the sandy, irrigated soil of West Virginia Pulp and Paper Company's nursery in South Carolina

Long Leaf's Life History

As the Paper Industry Invades the South, Here Is How the Plebeian Pine Is Cultivated by Far-seeing Paper Companies

PHOTOGRAPHS BY C. E. PATCH

NEWSPRINT from Southern pine is still, practically and financially speaking, just around the corner, but kraft paper and board is being manufactured in increasing quantities in the South. In the five-year period, 1928 to 1933, for example, Southern kraft-board tonnage increased from 97,200 to 433,700, while Northern tonnage was declining from 113,700 to 81,300. At present, large mills are under construction in South Carolina, Texas, and other Southern states. In the next quarter century the loblolly, the slash, and the long leaf may bring prosperity to many near-moribund towns in that strip of scraggly pines, some 150 miles wide, that sweeps down the coast from Virginia to Texas.

One of the great advantages of Southern pine is the rapidity with which it grows. The adjacent pictures tell the story of this growth, but implicit in them is another and more important story. Not even pine trees rising to maturity in 25 or 30 years could keep pace with an expanding paper industry that made no efforts to conserve and replant. There are evidences, as these pictures testify, that the more intelligent stumpage owners are coöperating in reforestation programs and are learning the art of silviculture.

In some sections of the South the natural-growing fifth-year pompons are cut and sold in the North for Christmas decorations, a practice which is causing apprehension in the ranks of conservationists. Other facts about long leaf: The trees bear a heavy crop of seeds only about every fifth year; the wood cannot be floated to the mill because some of it is too heavy to float even in brackish water; cost of Southern pine is about a third less than Northern hemlock or spruce.

MATURITY: DESTINED FOR PULP

POMPON: FIVE YEARS LATER

Transplanted to denuded areas, the seedling looks like this after four years. Over this long period the pine displays little obvious growth, the white bud remaining at ground level, amply protected by the pompon of long needles. What happens is that the plant grows downward; unseen, the taproot penetrates the soil three or four feet in preparation for the rapid growth just beginning at the stage this picture was made

ADOLESCENT GAWKINESS AT NINE

After five years the tree makes great strides until the 15th year, when a slower pace is assumed. By the time it is 25 or 30 years old, depending on soil conditions, it is large enough to be used for pulpwood and is cut by two-man crews, as shown at the left

The Philosophy of Science

Fifth in a Series of M.I.T. Library Reading Lists

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BARRY, FREDERICK. The scientific habit of thought: an informal discussion of the source and character of dependable knowledge. Columbia University Press, 1937.

BRIDGMAN, P. W. The logic of modern physics. Macmillan, 1928. Hollis professor of mathematics and natural philosophy at Harvard.
"No recent book on physical science of any real value has equaled 'The Logic of Modern Physics' for its logic, its sweeping vision, its economical and consequently esthetic consideration of a subject which interests and intrigues all men." — *The Nation.*

———— The nature of physical theory. Princeton University Press, 1936.
"Packed solidly with characteristic Bridgman hard-headed opinion, covering experience, thought, language, logic, mathematics, relativity, and wave mechanics." — W. M. Malisoff in *Philosophy of Science.*

BURTT, E. A. The metaphysical foundations of modern physical science: an historical and critical essay. Revised edition. Harcourt, Brace, 1925.
"Let no plain man be scared away by the word metaphysical in the title." — *Saturday Review of Literature.*

CASSIRER, ERNST. Substance and functions; and Einstein's theory of relativity. Translated by W. C. Swabey and M. C. Swabey. Open Court Publishing Company, 1923.
"A work deserving the closest study on the part of logicians, natural scientists, and philosophers." — *Isis.*

COHEN, MORRIS R., and ERNEST NAGEL. An introduction to logic and scientific method. Harcourt, Brace, 1934.
"As an elementary introduction to the meaning and function of logic, this book is quite valuable. It is intended to introduce its subject to college students, but it may profitably be read by the general reader. The whole book is suffused with concrete, everyday illustrations." — *Isis.*

DANTZIG, TOBIAS. Number, the language of science: a critical survey written for the cultured nonmathematician. Second edition, revised. Macmillan, 1933.

DAVIS, HAROLD T. Philosophy and modern science. Principia Press, 1931.
"A review of past and current beliefs, replete with quotations and references . . . intelligible to the layman and valuable to the scientist." — *Isis.*

ENRIQUES, FEDERIGO. Problems of science. Translated by Katharine Royce; introductory note by Josiah Royce. Open Court Publishing Company, 1914.
"Most thorough and synthetic treatment of the problems of scientific methodology. . . . [The author] approaches his problems with the training of the mathematician and the logician." — *Introduction.*

JEVONS, WILLIAM S. The principles of science: a treatise on logic and scientific method. Second edition. Macmillan, 1924. [Preface, 1877.]
"A classic, too important to omit." — Tenney L. Davis, '13.

KEYSER, CASSIUS J. Mathematics and the question of cosmic mind; with other essays. Scripta Mathematica, 1935.
"Reprints, with some alterations, of articles that have recently appeared in the *American Scholar, Scripta Mathematica,* and the *Yale Law Journal.*" — *Preface.*

LEE, RICHARD E. Backgrounds and foundations of modern science: an integration of the natural sciences for the orientation of college freshmen. Williams and Wilkins, 1935.
"A very proper use for Professor Lee's book would be in a graduate seminar by students who had already acquired the things which are supposed to constitute a liberal education. It would polish them up, tie their ideas together, and make them educated. The more one knows, the more, we believe, he will find in the book to question, and the more to stimulate him." — Tenney L. Davis in *Journal of Chemical Education.*

LENZEN, VICTOR F. The nature of physical theory: a study in the theory of knowledge. Wiley, 1931.
"Stimulating analysis of physical concepts and theories." — Leigh Page in *Science.*
"Valuable source of information for the philosopher who is seeking to recast his epistemology. . . ." — H. T. Davis in *Isis.*

NEEDHAM, JOSEPH. Order and life. Yale University Press, 1936.
"By the justly famous biochemist of the University of Cambridge. It is an erudite volume, intended for the serious student of the philosophical aspects of biological science." — Scientific Book Club *Review.*

PEIRCE, CHARLES S. S. Chance, love and logic: philosophical essays. Harcourt, Brace, 1923.
Scientific methodology from the viewpoint of a logician, the founder of pragmatism.

PLANCK, MAX. The philosophy of physics. W. W. Norton, 1936.
"Every physicist and most philosophers will put it on their required list." — Scientific Book Club *Review.*

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"The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful." — The author.

RITCHIE, ARTHUR D. Scientific method: an inquiry into the character and validity of natural laws. Kegan Paul, 1923. The author is lecturer in chemical physiology at Manchester University.

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"The methodology of the science of history." — Tenney L. Davis.

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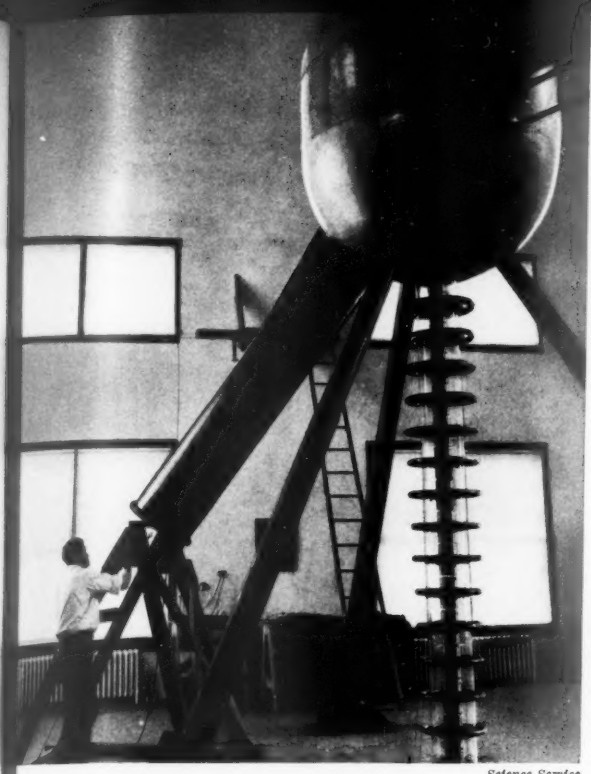
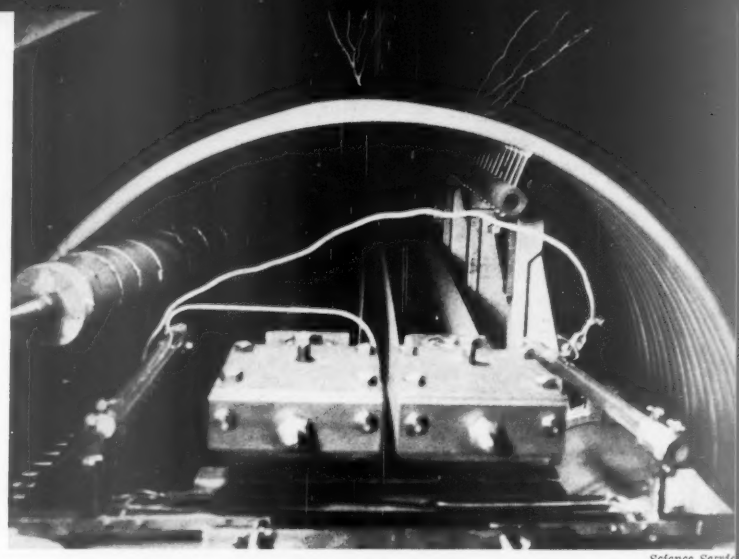
"The scientific aim, mood, and method are described, and illustrated by apt quotation from the works of active investigators." — *Nature.*



Science Service

AT THE CARNEGIE INSTITUTION



Science Servic

AT THE UNIVERSITY OF WISCONSIN

HEAVY ARTILLERY

. . . with which Science is waging its steadily intensified attack on the "world buried deep in the void within the atom — a mystery, an anomaly: the massive, dominating, all-powerful nucleus."

To penetrate this arcane fastness and to resolve the anomaly, physicists have invented two major types of bombardment apparatus involving the production of high voltages: the cyclotron of Professor E. O. Lawrence of the University of California and the electrostatic generator of Professor R. J. Van de Graaff of M.I.T. Presented here are samples of both types (cyclotron: Michigan, California; electrostatic generator: Carnegie, M.I.T.).

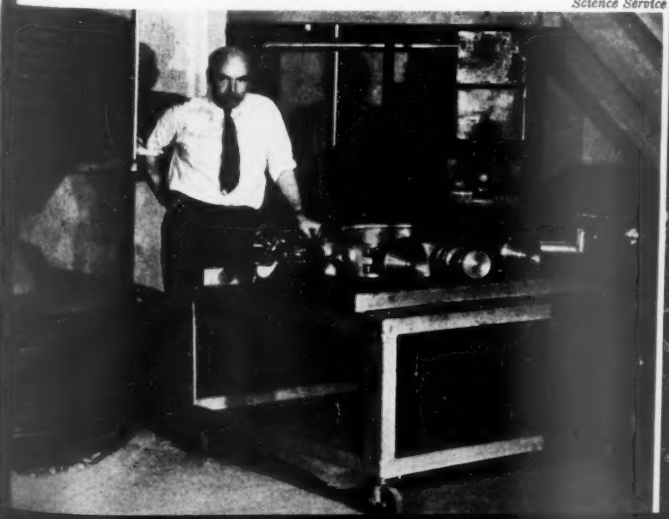
The Wisconsin atom smasher, which will develop a potential energy of 2,500,000 electron volts, is shown in the picture, discharging a 600,000-volt spark. Michigan's cyclotron, weighing over 95 tons, is the largest of the 26 in this country. At California the original cyclotron shown in the picture is being replaced with a new one that will dwarf all other smashers of the particle-accelerating type. At M.I.T. is the Cyclopean patriarch of the electrostatic generators for which the tube to connect the two spheres is now being completed. The Carnegie Institution in Washington has achieved remarkable results with its variation of the Van de Graaff generator and has announced plans for a larger one.

Newest name for an atom smasher is the chic and delightful rumbatron *coined at Stanford University for a variation, now abuilding, of the Lawrence bombarder*

AT M.I.T.

AT THE UNIVERSITY OF MICHIGAN

Science Service



AT THE UNIVERSITY OF CALIFORNIA

Science Service

Technics and the Woman

A Distaff (and Possibly a Minority) Report on the Age of Science

By Eve Withers

Illustrated by Henry B. Kane

THE present age has more names than it needs. We are told constantly by this or that informer that it is the Age of Progress, the Age of Enlightenment, the Machine Age, the Age of Science, the Age of Electricity. Once in a while it is hailed as the Age of the Emancipation of Woman. More often, however, proponents of Progress, or Enlightenment, or Freedom, as the proper denominator for a paradoxical period, lug in the emancipation of woman as one of the prime examples of the accuracy of the name to which they are devoted. Many of these contests are disposed of if we decide to call our era the Age of Science; this is one of those conveniently inclusive terms which clear up arguments very nicely. And it is the truest term if we consider the dominant activities of the civilized world during the present and the past three centuries.

Science, in spite of such achievements as those of Madame Curie and a few other women, has, however, necessarily been mainly the concern of man. Lest this essay appear thus early to be but another barrage in the age-old War between Men and Women which Thurber has recently depicted anew in *The New Yorker*, it is well here and now to show that man's monopoly of scientific activity has not resulted from selfishness or deliberate exclusion of woman from the laboratory and the machine shop. In the beginning of the scientific age, when Faustian man was starting the search for exact knowledge, woman, because of lack of education and of opportunity, could not have much to do with the development. The lack of education and opportunity was in large measure voluntary; woman in the pre-scientific age had work to do and a position to fill for which external training was not essential. She was not dissatisfied with the work she had to do. The making of the world a comfortable and satisfying place offered her full scope; man might use his talents for the same purpose, as best suited him. As a consequence, she was for a time debarred or withdrawn from much participation in engineering — the material extreme of science which most obviously affects the greatest number of lives.

The other extreme of science has always been a dominantly masculine concern for a profounder reason. Philosophically, science is essentially a questioning of bases, of origins — an activity to which the male mind has always been inclined. It is man who spends time and energy speculating on the origin of life; woman doesn't bother so much about it because she has a more intimate knowledge of the subject through experience, or if not through experience, at least through adaptation. Best witness to the truth of this assertion is the pronounced majority of male over female Messiahs in history. Woman by her nature instinctively holds to the *status quo*, especially in matters philosophical, for reasons that will appear. As for her attitude toward lesser matters, the hirsute brag that no woman ever invented a device to lighten her housework finds its answer in the fact that if necessity is the mother of invention, woman did not feel the necessity.

Whether as the result of the romantic urge to worship an ideal, or of the instinct to propitiate something not understood, or of the simple desire to demonstrate his masterfulness, man has spent most of his lifetime in collecting trophies for woman. Many of them please her, tickle her vanity at least, if they do not give her deeper gratification. Others necessarily puzzle her, for they are the things which man gives her, not because he thinks she wants them, but because he wants to give them to her. Like all masculine undertakings, science too has been put to work by man's trophy-collecting urge as another means by which big-hearted Otis may make the little woman happy and in so doing may make himself happy by proving his prowess.

. . . the Origin of Life . . .

Possibly by a mere accident of time, but probably because of the widening of mind which scientific investigation must bring with it, the beginning of the emancipation of woman, so-called, occurred about as science began to dominate life. Because he had ready to his hand the apparently unlimited fecundity of science as a source of things, devices, techniques, man used science and its results as an important part of the process of emancipation. Especially in its engineering aspects, science has been called upon in a myriad ways to set women free from this, that, and the other kind

. . . woman had work to do . . .

of drudgery. The spread of the scientific spirit has been accompanied by the increase of educational training for women. Likewise hygiene and physical welfare have been made self-conscious and thereby often improved. In another department, enfranchisement has been conferred on woman. The business woman, limited as she may be in number and hampered as she may be in a competition for which she was not basically meant, is heralded to be as significant a symptom of the scientific age as is the Zeppelin. Not all of these developments, it is true, are directly attributable to science as represented by the test tube, the laboratory coat, or the slide rule. But the lightening of housework, the apparent easing of physical handicaps, the creation of opportunities for work outside the confines of the kitchen, the dairy, or the schoolroom, and the enlargement of the scope of educational opportunity — for these, woman may and does in the large sense look to science.

To put the case in extreme terms, the file which cuts the manacles from the slave is the benefactor of the slave; science, then, is regarded as the benefactor of woman, not of woman as part of mankind in general, but of woman as a creature separate and distinct from the male who devised science and put it to work in aiding her emancipation from what he saw as bondage. Whether he as man, or mankind as a general thing, or woman as woman, or the conditions of life on this planet imposed the bondage on her doesn't much matter to him. Man at least thought her state of dependence and inconsequence was bondage from which he should set her free.

. . . earth, not velvet . . .

In reasoning, as in terminology, however, this case is exclusively masculine. To man, his own state appeared, conversely, to be one of independence and consequence because he was free of what to him seemed the drudgeries of life. Therefore he reasoned that to take away from woman the work of dependence and inconsequence would emancipate her. Serene in his closed system, he ignored the fact that it was closed, that he would keep it closed to her whether she came to it lugging a broom or pushing a vacuum cleaner. Since man controls science and has used it to implement his fallacy science has not been a benefactor of woman, in the large sense; rather, it is a means reducing her to a futility worse because it appears so useful. This is a serious accusation; to support it, we must look beyond the immediate appearance of the case. It is perhaps an unfortunate thing for science that any attempt to appraise it and its effect on any institution easily becomes wrapped up in the more obvious and more numerous impacts of engineering on life, and consequently slights or even ignores the much more powerful and permanent effects of science philosophically.

. . . adding machine for washboard

Equipped with a vacuum cleaner which weighs more than a sledge hammer, the little woman remains at home with her telephone to call the chain store for jiffy desserts; with that supersalesman, the radio, to advise her on doubtful cures for all ills; and with the rest of the button-pushing paraphernalia of her brave new world, a new world which is to her, for all its virtues, a contradictory one; for woman cannot agree that, were efficiency ever entirely possible or always entirely pleasant in a home, science has lived up to the claims made for it. For example: An electric dishwasher is to a woman only another means of doing the same old task. It may free her from the kitchen for a longer part of the day, but it cannot collect the dishes, scrape them, rinse them, stack them, or return them to the pantry shelves — all, in fact, that it does, is to give her a machine to manipulate and make her kitchen look less like a comfortable room and more like a unit in a factory or hospital. Call it feminine perversity if you will (a more likely explanation is the fact that most women have a blind spot mechanically), but so it is with woman in regard to the machines which she is urged to accept as more efficient substitutes for her own two hands and her ingenuity. The household drudgery from which she is supposed to be set free is essentially the day-after-day repetition of tasks which are in themselves pointless because they are never completed or because they are automatic and give no opportunity for creative thought or activity. The installation of a machine which is touted as the thing that will do the task is but a disillusionment to her when she finds not only that it will not do the task completely, but that it forces on her merely another kind of pointless routine, or that it does only the part of the task which was in no way objectionable to her. Man, whose efficiency is measured by the number of people who jump when he pushes a button, finds it hard to understand why woman should be dissatisfied with the button-pushing opportunities which science has given her. He does not remember that when she has pushed the button, she must run around and do the jumping.

. . . collecting trophies for women

The mechanical contrivances which science has given woman cannot, however, be generally condemned; on the grounds of efficiency as doers of work they must be admitted to be improvement and advance over the past. Obviously, it is better and easier to draw fairly pure water from a faucet than to carry it in buckets from a possibly polluted well. Man and science are in a tenable position when they argue that woman is better (*Continued on page 128*)

THE INSTITUTE GAZETTE

PREPARED IN COLLABORATION WITH THE TECHNOLOGY NEWS SERVICE

Fellowships

FOUR fellowships named in honor of the late Dr. Arthur D. Little, '85, long a member of the Corporation and one of the Institute's most distinguished Alumni, have been established in the Graduate School. Two of these honors will be known as the Arthur D. Little Postdoctorate Fellowships and will carry stipends of $1,500 each, with facilities for research in the Institute's laboratories. The other two fellowships, designated as the Arthur D. Little Fellowships, are open to graduate students pursuing studies for the doctor's degree in chemistry or chemical engineering. They carry stipends of $1,000.

Announcement of the new fellowships was made on December 15 by Dr. Harry M. Goodwin, '90, Dean of the Graduate School, at the dedication of the recently established industrial museum in the Arthur D. Little laboratories on the occasion of the fiftieth anniversary of this widely known research organization. The fellowships constitute two of the four types of scholarship aid described in President Compton's plans for expansion.

Key to a Gelid World

SCIENTISTS have long known that the ability of magnetic fields to change or distort matter, thus altering its properties in a great variety of ways, held exciting possibilities for exploring new frontiers in the world of matter. For such fundamental research magnetic fields of great strength are necessary and the quest for methods of producing them has been carried on intensively for many years. Until recently, however, the types of apparatus available met the demands only partially, either because the intensity of the desired fields was obtained for only a fraction of a second, or because, as in the case of the iron-core magnet, the fields covered too small a volume for practical applications.

In the light of all the effort that has been devoted to this study, it is therefore especially significant that a magnet capable of producing a field of great intensity and long duration has been developed at the Institute. The new magnet, a pygmy in comparison with others less powerful, produces a field approximately 150,000 times stronger than that of the earth. The Institute's magnet was designed to produce fields of at least 100,000 gauss, the highest permanent field ever attained, and in preliminary tests under the direction of its designer, Dr. Francis Bitter of the Department of Mining and Metallurgy, a field of 75,000 gauss was produced. The enormous amount of power required to produce this field was made available to Dr. Bitter through the coöperation of the Edison Electric Illuminating Company of Boston, which placed at his disposal laboratory space in one of its large substations. Here, with controlled, direct current up to 12,000 amperes at 250 volts to draw upon, the first test was successfully carried out with a maximum current of 8,000 amperes, producing a field of 75,000 gauss.

The copper coil of this unique magnet, which is only six inches in diameter with an inside diameter of one inch, is inclosed in a bronze shell. A water-cooling system is employed to dissipate the enormous heat generated when an amount of power sufficient to supply a small town, or more energy than is needed to operate 50 automobiles of 80 horse power, is poured into this amazingly small piece of apparatus. Without water cooling the magnet would melt within one second. Because of the very heavy power load and the strength of the magnetic field, precautions were taken to protect the research staff and the electrical machinery. The two huge bus bars carrying the current to the magnet each consisted of six strips of copper, six inches wide and a quarter of an inch thick, bolted together.

Having decided upon the design, Dr. Bitter built a small experimental magnet consisting of a copper coil two inches in diameter and one inch thick, embedded in a block of low-carbon steel. Operating with 25 kilowatts, this little magnet produced a field of 35,000 gauss over one cubic centimeter. The experience gained from the experimental model led to the construction of the 100,000-gauss magnet, and a still more powerful model capable of producing an intense field over a much larger volume is now in process of design. Dr. Bitter's experiments were made possible by grants from the Penrose Fund of the American Philosophical Society and from the Joseph Henry Fund of the National Academy of Sciences.

The stimuli for the present investigation in magnet design are of two kinds: First of all, it is desired to explore new regions quite without any possible prediction as to what lies in store. A magnetic field distorts or changes matter and, therefore, also its properties. With the new magnets it is now possible to produce greater changes than with older models and at the same time vary the conditions of the experiment, such as temperature and pressure, and still have ample room and time for accurately observing the changes that take place. Previous experiments have shown that at low temperatures magnetic fields can make certain salts as magnetic as nickel, and that certain metals which normally are good conductors of electricity can be made relatively nonconducting. The whole range of existing substances, from pure gases, through liquids, solids, compounds, solutions, alloys, organic, and biological matter is available for experimentation. The value of the results obtained will probably not be in the form of new useful forms of matter or new means of controlling chemical and physical changes, although such results are conceivable, but rather in revealing inadequacies in the present theories and in pointing the way to more correct thinking.

The second stimulus for the present investigation in magnet design is to make a generally useful laboratory tool and to fill specific needs in a variety of investigations already under way. For example, the very interesting range of temperatures below one degree absolute can be reached by means of a magnetic cooling cycle, and the new magnets should be well suited for such work. Dr. Bitter will collaborate with Dr. Frederick G. Keyes, Head of the Department of Chemistry, next spring in a program of low-temperature research by means of the intense magnetic fields now available in the new type magnet. This apparatus is expected to be used also for accurate measurement of the Zeeman effect, which is the splitting up of the spectral lines by a magnetic field for the study of atomic structure. The magnetic method may also be employed for the study of very fast-moving atomic particles.

The fascination of exploring the inconceivably cold and mysterious world of matter in the neighborhood of absolute zero lies in the fact that rapid and strange changes occur when matter is subjected to extremely low temperatures. Absolute zero, which corresponds to 459.69 degrees below zero F., is the point at which scientists believe heat ceases to exist in matter, where molecular motion is reduced to a minimum. In this region every minute step down the scale of temperature is of enormous significance. A fraction of a degree may conceivably change matter from one state to another as heat is withdrawn.

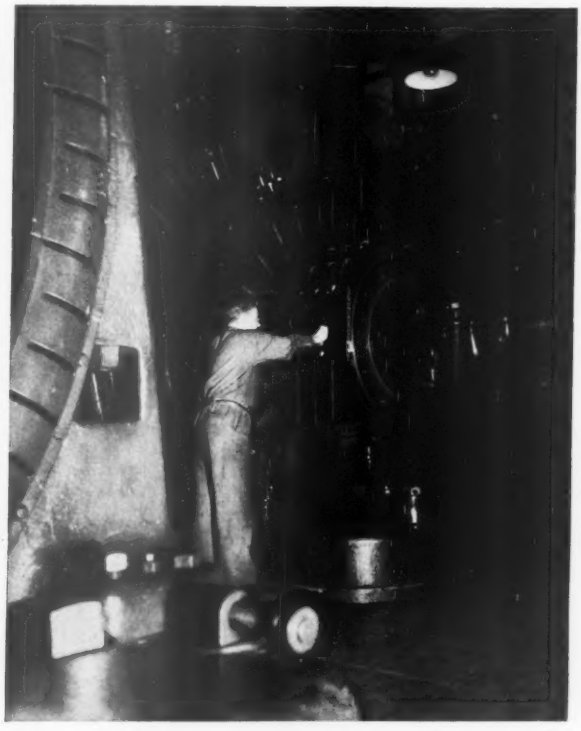
The search for new knowledge in the field of low-temperature research is made possible because certain complex salts, such as ammonium chromium alum, can be made to give up heat under the influence of a magnetic field. To accomplish this, most of the heat in the salt would first be absorbed while in an intense magnetic field by boiling liquid helium, a method which makes it possible to reduce the temperature to 2.34 degrees F. above absolute zero. The next step is to shut off the field, protecting the material from heat influx. The temperature is thus still further reduced to the region of approximately 0.2 degrees above −459.69.

The electrical conductivity of metals and even some nonmetallic substances becomes limitless under the influence of extremely low temperatures, which means that under ideal conditions it is conceivable that an electric current, once started, would continue to flow undiminished for all time. A similar effect is manifest in the heat-conducting properties of substances. Thus the wholly different and astonishing world of physical properties revealed in future low-temperature research may profoundly affect the existing theories of the structure of matter.

Step by Step

THE technique of the industrial designer, revealing the various stages in the design of a wide variety of familiar products, is graphically represented in a unique exhibit in the Institute's School of Architecture. This interesting exhibition, which will continue until January

THIS SMALL MAGNET SWALLOWS THE OUTPUT



. . . OF TWO GENERATORS LIKE THIS

The left illustration shows Dr. Bitter and the new magnet, behemoth in power though a pigmy in size, designed by him to produce a field of at least 100,000 gauss. For what it does, how it excels, what it may do, see adjacent story

9, shows the various steps, from rough sketches to finished drawings, of such products as electric fans, clocks, automobile parts, fabrics, bottles, and furniture. The aim of the exhibition is to indicate how the designer works and to show the nature of his contributions which, with efforts of executives, technicians, salesmen, and many other people in the background, form the development of familiar products.

Behind each product when it finally is offered to the public is a long biography becoming, through technological progress, more complex as it advances from stage to stage. Industrial design forms an increasingly important phase of this complexity, and the exhibition represents only a few of the more important high lights in the biographies of a number of products. It offers, in addition, some interesting biographical information on the designers themselves, because each has selected material to show how he worked out a particular problem. The work in each case was chosen because it represented some interesting point or points in technique rather than because of the importance of the product itself. Brought out clearly in the exhibit is the process by which a designer changes his own artistic conception of the finished product in order to adapt it to the demands of the consumer and of quantity production.

Many of the exhibits show the working steps in the process of design, including original rough sketches, blue prints, drawings at various stages of development, survey material, variety in results, and, in some cases, the marketing methods. The number and variety of technological processes involved in the planning of industrial products, from bottles to automobiles, are represented and indicate the wide range of interest which the showing offers, particularly to manufacturers.

Theodor Carl Müller, '26, lecturer on design of manufactured products at Technology, has assembled for the exhibit the work of a number of the foremost men in the field of industrial design, a phase of manufacture which involves the design or redesign of more than 8,000 products annually. Among the prominent industrial designers who have sent samples of their work are De Vaulchier and Blow, exhibiting clock designing; Georges Wilmet, perfume bottles; Virginia Hamill, textiles; Robert Heller, electrical equipment; Belle Kogan, silver; Ben Nash, packaging and radios; Gilbert Rohde, furniture; Morris Sanders, bottles; Roy Sheldon, designs for use of new low-cost moulding material; Walter Dorwin Teague, automobile parts; Sidney Waugh, '27, glassware; Russel Wright, radios. Other exhibitors include Egmont Arens, Norman Bel Geddes, Lurelle Guild, Egbert Jacobson, Gustav Jensen, Raymond Loewy, Alfred L. Mell, George Switzer, John Vassos, and Walter Von Nessen.

To Nine Unknowns

TO the Institute's distinguished achievements in the development of mechanical calculating machines for the solution of mathematical problems in science and engineering is now added the simultaneous calculator. The new machine, designed and built in the Department of Civil and Sanitary Engineering by Professor John B. Wilbur, '26, is capable of solving nine simultaneous linear algebraic equations. During the three years in which the new machine has been under development, Professor Wilbur has had the close coöperation of Dr. Vannevar Bush, '16, Dean of Engineering, whose own contributions in the field of mechanical solutions of mathematical problems, including the differential analyzer, have received wide recognition.

Equations of the type solved by the new machine constantly occur in engineering and scientific analyses covering a wide range of fields. Designed originally for the solution of problems in civil engineering, such as the complex calculations that arise in the design of skyscrapers, the calculator promises to be useful in such diverse fields as nuclear physics, geodetic surveying, genetics, and psychology. For the mathematician it is a new tool for the evaluation of determinants. Once the coefficients and constants of the particular equations to be solved are set up on the new calculator, a single movement of the mechanism accomplishes mechanically in a few seconds mathematical processes which might take days if carried out by the usual methods of calculation.

The simultaneous calculator, which weighs 2,000 pounds and has more than 13,000 separate parts, including 600 feet of flexible steel tape and nearly a thousand ball-bearing pulleys, is the outgrowth of an experimental laboratory model built by Dr. Wilbur in 1934. The new machine has undergone exhaustive tests and is now in active operation. Construction of the simultaneous calculator was made possible by a fund established by Sir Douglas Alexander of New York. Built for the direct solution of nine simultaneous equations involving nine unknowns, the machine may be operated to solve equations containing even a larger number of unknowns. Accuracy of results to any degree required may be obtained by successive solutions, each one yielding greater accuracy than its predecessor.

New Funds

GIFTS to the Institute amounting to more than $23,000 were announced by President Compton at the meeting of the Alumni Council on November 30.

Securities of a value of $10,000 have been presented to the Institute by Godfrey L. Cabot, '81, for aeronautical engineering and general purposes. Part of the gift is expected to be devoted to the fund for construction of a new wind tunnel of unique design. Dr. Compton stated that in addition to Mr. Cabot's gift, a substantial sum has been pledged toward the construction of the wind tunnel. The donor is president of G. L. Cabot, Inc., and has long been active in the advancement of aviation.

An anonymous gift of $10,000, to be known as the Bess Bigelow Fund, was also announced. The fund will be used for scholarships, research, and other educational purposes at the discretion of the Corporation.

The family of the late Henry A. Morss, '93, who, as a life member of the Corporation, was active in its affairs for many years until his death last May, has presented a gift of $3,500 to be used for the Institute's undergraduate sailing activities. Mr. Morss, much interested in yachting, was a member of the original committee which had charge of the design of the Technology dinghies.

Kenneth Roberts, the author, has presented to the English Department a valuable collection of material gathered during the writing of "Arundel," his novel on Benedict Arnold's march on Quebec. The collection includes the original manuscript of "Arundel" with the author's working notes, correspondence, various books, including the histories of several Maine towns, and a copy of the first edition of the novel, which appeared later in a revised form. In the collection also are several maps, among them being one of the Lake Megantic region of Quebec, photostatic copies of Benedict Arnold's letters, and the original drawings of the end papers for the novel.

Cosmography

DR. HARLAN TRUE STETSON, astronomer and physicist, has been appointed a research associate on cosmic terrestrial relationships at the Institute. With special facilities at his disposal at Technology, Dr. Stetson will continue an important program of cosmic terrestrial research which has already led into the fields of geophysics, the physics of the atmosphere, and the field of radio communication. He is particularly interested in the earth's crust, an investigation which involves studies of small variations in latitude and longitude.

Dr. Stetson is a native of Massachusetts and a graduate of Brown University, Dartmouth College, and the University of Chicago. From 1911 to 1913 he was an instructor in physics at Dartmouth College, where he began a series of experiments which resulted in the development of the first thermoelectric photometer for determining the stellar magnitudes from photographic plates. In 1913 Dr. Stetson joined the staff of Northwestern University as an observer at the Dearborn Observatory and instructor in astronomy. His graduate work leading to the degree of doctor of philosophy was carried on at the University of Chicago and in the autumn of 1916 he was appointed instructor in astronomy at Harvard University and Radcliffe College. His appointment as assistant professor of astronomy at Harvard came in 1920, a position which he held until he accepted the post of director of the Perkins Observatory and professor of astronomy at Ohio Wesleyan University.

Dr. Stetson is a fellow of the American Academy of Arts and Sciences, the Royal Astronomical Society, the American Association for the Advancement of Science, and many other scientific societies in this country and abroad. He is the author of several books on astronomy and has contributed numerous technical papers to the scientific journals.

United Research

THE rewards of coöperation in research in the field of metals through joint investigation of fundamental problems by physicists, metallurgists, and chemists will be discussed by leaders in these fields at a meeting to be held at the Institute on January 28 and 29 under the auspices of Technology and the American Institute of Physics.

M.I.T. Photo

ENGINEER'S DELIGHT

. . . Is this machine designed by Dr. Wilbur — who sits beside it — for solving up to nine simultaneous equations.
See full details on opposite page

The forthcoming meeting emphasizes the promising trend toward a most productive type of research in which technical workers bring to problems of fundamental interest the specialized knowledge and methods of their several fields. The very important results of joint research are nowhere more evident than at the Institute itself, where many investigations are brought to successful conclusions through interdepartmental cooperation.

The purpose of the meeting is to discuss thoroughly recent developments in the physics and chemistry of metals, as well as the opportunities for still greater advances through the combined coöperative effort of all workers whose knowledge may in some way contribute to problems of mutual interest. From a half to one hour each will be allowed for presentation of the important papers, and ample time will be given for discussion, thus permitting an interplay of viewpoints not possible in the usual scientific meeting.

Some of the more general papers to be presented are: "Research Problems in the Steel Industry," by Dr. E. C. Bain, United States Steel Corporation; "Inclusions in Ferrous Alloys," by Dr. A. B. Kinzel, '21, Union Carbide and Carbon Corporation; "Flow Phenomena in Heavily Stressed Metals," by Professor P. W. Bridgman of Harvard; "Electronic Structures in Metals and Alloys," by Professor J. C. Slater, Head of the Institute's Department of Physics; "Corrosion," by Dr. J. R. Burns of the Bell Laboratories; "Elastic Properties of Ferrous Alloys," by Professor A. V. de Forest, '11, of Technology; and "Chromium-Nickel-Iron Alloys," to

be discussed by Dr. V. N. Krivobok of the Allegheny Steel Company. In another group of papers various techniques and their applicability are to be presented, while in the third group some especially complex scientific problems met with in ferrous alloys will be discussed.

Arrangements for the meeting are in charge of Professor John C. G. Wulff of Technology, who will act as secretary, and Dr. Harry A. Barton, Director of the American Institute of Physics.

Accredited Curricula

ALL of the Institute's engineering departments and courses have been accredited by the Engineers' Council for Professional Development in a survey of undergraduate engineering curricula in educational institutions of New England and the Middle States which has recently been completed. The Engineers' Council for Professional Development is a conference of engineering societies organized to enhance the professional value of the engineer through the coöperative support of national organizations directly representing the professional, technical, educational, and legislative phases of the engineer's life. The participating societies in this significant undertaking are the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, the Society for the Promotion of Engineering Education, and the National Council of State Boards of Engineering Examiners.

Only curricula in institutions making application to the Council were considered, and the names of various institutions will be added to the Council's list of accredited curricula from time to time. The Council's committee on engineering schools, of which President Compton is chairman, made the study of the institutions in New England and the Middle States, and a survey of curricula of institutions in other parts of the country will be undertaken during the coming year. In compiling its list of accredited engineering curricula, the Council considered every curriculum separately and based its decision on the reports made by a number of groups of engineers and educators who visited the various institutions. Only undergraduate curricula leading to degrees were considered.

Technology's engineering departments and courses accredited by the Council are Aeronautical Engineering, Architectural Engineering, Business and Engineering Administration, Chemical Engineering, Civil Engineering, Electrical Engineering, Electrochemical Engineering, General Science, Mechanical Engineering, Metallurgy, Mining Engineering, Naval Architecture and Marine Engineering, and Sanitary Engineering.

Alumni Council Meeting

A WARM greeting to its guest of the evening, Dr. William D. Coolidge, '96, marked the Council's 190th meeting on November 30, as did President Compton's announcement of gifts (see page 118). In the line of business there were two important progress reports, that of John E. Burchard, '23, on the Friends of the Library and that of Raymond S. Stevens, '17, on the comparative merits of a new gymnasium or an enlargement of Walker Memorial in the proposed program for student welfare. From designs prepared by Dr. Harlow Shapley and his Corporation Committee and by Mr. Burchard and his Alumni Committee, the Friends of the Library has its foundation laid and its framing well under way. A special article is planned for an early issue of The Review to detail these plans.

Mr. Stevens remarked that the solution of the problem tackled by his committee seemed perfectly obvious — with no one agreeing as to what *obvious* is. He then gave examples of the many reports and briefs that he had received from special groups, all desiring additional space either in an athletic building, an auditorium, or Walker Memorial. It is the duty of this committee to sit in judgment on the appeals of these special interests and render a decision as to what is beneficial to the greatest number of students.

It was regrettable that the Council, as a deliberative body, sat tongue-tied and in discouraging silence when President Robbins, '07, called for discussion of Mr. Stevens' report. The Council seems to have lost the desire to talk; it only wishes to be talked at. Despite a really distinguished history of vigorous and profitable debate, the Council has now become forensically obese and deliberatively mute, leaving its work to committees who do it, we hasten to interject, extremely well, even when they come to the Council for aid and receive, not the bread of discussion, but the stone of silence.

Sixty-five members and guests were present.

Visiting Committee Report

IN condensed form, we present below the most recent report to the Institute Corporation of the Visiting Committee of the Department of Biology and Public Health.

BIOLOGY AND PUBLIC HEALTH *

At the Committee's last meeting, Professor Samuel C. Prescott, '94, at the request of the Chairman, outlined the purposes and content of the three options of undergraduate study in the Department, namely: (1) biology and public health, (2) industrial biology, and (3) public health engineering. A discussion of the three programs followed, in which the studies were considered with reference to professional fundamentals and also with reference to those broader and more cultural aspects which are considered under the term general studies.

The Committee was of the opinion that the professional work was of high grade and of broad scope and should not be weakened in any respect. At the same time the desirability of the general subjects of social, economic, and literary character was recognized. It

(*Continued on page 124*)

* The members of this Committee for 1935–1936 were: Victor M. Cutter, Chairman, Henry E. Worcester, '97, Donald G. Robbins, '07, Charles E. Smith, '00, Harrison P. Eddy, Jr., '17, Lewis W. Waters, '10, Henry Vaughan, and Fred C. Blanck.

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LEADERS IN SOUND-TRANSMISSION APPARATUS

HEALTH HAZARDS IN INDUSTRY

(*Continued from page 110*)

use of a simple gauze respirator over the mouth and nose will eliminate all difficulty. The mask must be efficient to resist passage of the particular dust, of course.

The foregoing conditions will serve as examples of industrial diseases which consist simply in overuse of the protective mechanism of the body. Although the conditions may be very disabling, they are superficial, consisting in a breakdown of some part of a local protective surface. In contrast, a few general effects can be mentioned, which follow physical phenomena or absorption of substances.

Excessive heat is followed by the common industrial diseases of heat cramps, heat exhaustion, heat stroke, and so on. These conditions are general effects and are due directly to the changes in body metabolism following excessive perspiration. Water loss of perspiration is replaced by the drinking of ordinary water. This fluid, however, contains an insignificant amount of common salt, while perspiration contains from one-tenth per cent to two per cent of salt. The new, uninitiated workman, unused to hot work, has perspiration with the higher salt content. Obviously a salt deficit is possible by virtue of the absolute loss of salt in the perspiration; practically speaking, there are no reserves of salt in the body, and it is necessary to take in a few grams of salt each day to replace that normally lost. An unusual drain on the salt of the body, as in excessive perspiring, will obviously threaten the correct percentage of salt in the body fluids. A very small drop is accompanied by the signs of heat exhaustion or heat cramps. The immediate cure is the administration of salt to restore the normal concentrations. Prevention of these heat effects is accomplished through the administration of salt in the drinking water (two-tenths per cent — not detectable to taste), giving salt in tablet form, and a salt-adequate diet (equivalent to two quarts of milk daily).

Many other physical phenomena have definite effects on health. Considering radiant energy, the eyes are of primary concern. Metallic and carbon electric arcs are sources of much ultraviolet radiation of wavelengths of 295$\mu\mu$ and less, from which the eyes must be protected. If a burn occurs, painful symptoms are apparent several hours after exposure. Excessive cold, another physical phenomenon, is endured better by the body than excessive heat. With adequate clothing, any low temperature can be survived. Excessive dryness or the opposite, high humidity, are factors which have much to do with comfort of individuals. The actual presence or absence of moisture in the air is probably of doubtful health importance except that high humidity means damp, cold, and wet working conditions. Such exposure is conducive to frequent respiratory infections.

Inorganic materials when breathed into the lungs are the cause of pneumokonioses. All large particles, as are found in Nature's dust storms and so on, are easily trapped and eliminated from the air before they reach the deepest part of the lungs. However, in mining work after the use of explosives and in grinding, dust particles exist 10 microns or less in diameter. Such small masses, of course, float easily into the depth of the lungs. The particles, due to their smallness, are able to reach the vulnerable absorbing surface of the lungs. If the substance is harmful, it has a chance to be effective. Fortunately, however, many of our dusts are quite inert physiologically. The carbonates, phosphates, and so on, are water soluble and are easily eliminated from the lungs by the blood route. If these soluble dusts are specific poisons, such as lead, a general poisoning, of course, can result, due to their very quality of solubility.

A few dusts in industry have particular interest. The carbonaceous materials are not water soluble and remain stored in the lungs indefinitely without any effect apparently on the health of the individual. This condition, however, has a name and is called anthracosis. Dusts of asbestos — a complicated silicate — form plugs in the lung passages and, if not coughed up, can cause serious lung disease. This is asbestosis. The inhalation of iron oxide is apparently quite innocuous, but the condition is termed siderosis.

A dust in industry that is definitely related to health is crystalline silicon. It causes silicosis of the lungs, a disease that is attracting widespread interest at the present time. Silicon dioxide (common sand or quartz) is harmless as long as it is trapped in the nose and upper respiratory tracts. Particles of silicon must be so small that they pass into the true lung tissue (*i.e.*, less than 10 microns in diameter) before they are effective. A great deal of such silicon dust, however, does exist in industry. The dusts around the pneumatic drill of the miner, of sand blasting, of sandstone grinding, and so on, contain quartz in particles of about 10 microns in diameter. These are small enough to pass easily into the lungs. The respiratory defense of hairs and sticky surfaces cannot engage such particles.

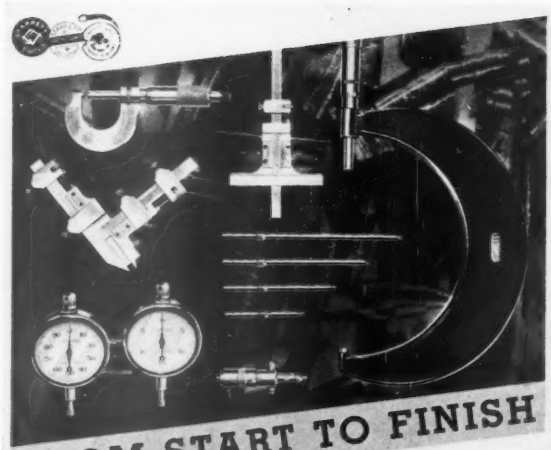
It usually takes years of exposure to produce the pulmonary lesions of silicosis. The result is to cause the lungs to lose much of their effective respiratory surface due to fibrosis whereby the breath becomes shortened and a variety of secondary changes follow. The entire disease is related to the subject of tuberculosis and in the final stages it is practically indistinguishable from it. In fact it is generally thought to be tuberculosis grafted on the original silicosis.

There is a final type of environment in industry which affects the health of man. This environment is air chemically contaminated by gases or fumes which pass as readily into the body as air itself. Obviously the body is powerless to prevent absorption. Some of these gases have no odor or unpleasant acute sensation associated with their absorption. They pass directly into the blood stream. The respiratory membranes in the lungs are simply tissues which allow the free interchange of gases between blood and air. The passage is governed by partial pressure phenomenon. Carbon monoxide is an example of a gas which is extremely poisonous and yet is absorbed readily. Hydrogen sulphide, in strength so great that its odor is not unpleasant, is another. Hydrocyanic acid and benzol are both absorbed readily. The differences among the poisons come in their action after absorption. Carbon monoxide so affects the blood that it loses its oxygen-carrying capacity. In a normal in-

dividual, unconsciousness from asphyxia results when somewhat less than half of the blood hemoglobin is in combination with carbon monoxide. Death will ensue rapidly if the carbon monoxide concentration continues to increase in the blood. Recovery is likewise rapid if oxygen and artificial respiration are applied. The carbon monoxide leaves the body apparently without permanent after effects except in rare cases where deep coma existed.

Carbon monoxide poisoning acts in much the same way as an atmosphere which is low in oxygen, and our knowledge of this poisoning gives us insight into the new field of aeronautical medicine. At the higher altitudes the lack of oxygen is probably the most important factor. A normal individual can usually go to 15,000 feet without being seriously affected by the lower oxygen content of the air. It is possible to forecast the reactions of persons to low oxygen atmospheres as they resemble the reactions to carbon monoxide gas. Persons with heart disease, lung disease, or anemia are particularly affected by carbon monoxide. The same people would first notice the effect of low oxygen partial pressure. The early symptoms of carbon monoxide poisoning are giddiness, shortness of breath, faintness, weakness of the lower extremities, and pounding of the heart. These are precisely the symptoms of high altitude or mountain sickness.

It is obvious that the many kinds of environment present in the modern factory demonstrate the great adaptability of the human body to resist damage, but it is equally obvious that there are many industrial environments which overstrain the protective power of the body. It is to be hoped that working conditions can be improved to a point where the strain on the physiological adaptability can be entirely removed. With new materials and processes constantly being introduced, a great deal of attention is necessary to accomplish this program. Extensive laboratory facilities, specifically designed for the study of toxicology and pathology are necessary; physicians must be available to detect the signs and symptoms of disease; and engineers with a knowledge of industrial hygiene must be present to redesign operations or to construct ventilating devices to clear the environment of noxious fumes and gases. In large companies enough problems arise to maintain a complete laboratory, such as the Haskell Laboratory of Industrial Toxicology of the DuPont Company of Wilmington, Del. In addition, departments of industrial hygiene are maintained in a number of our universities in connection with medical schools and schools of public health. Insurance companies, too, are recognizing the value of undertaking intelligent research in this field of industrial environment. The United States Public Health Service maintains a division devoted to industrial health problems which is at the service of the public. Various states also have departments similar to this organization. The field of industrial hygiene is attracting much attention at the present time and consequently more state departments are being organized or enlarged each year. All of these organizations are contributing to the problem of improving industrial environment in order to eliminate all factors detrimental to health.



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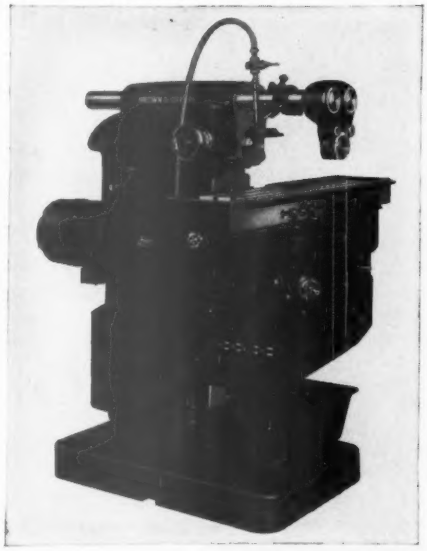

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INSTITUTE GAZETTE

(*Continued from page 120*)

was the viewpoint of the Committee, however, that these should not be greatly extended, especially if to do so would be at the expense of the professional training, but that every effort should be made to stimulate interest in cultural and social studies by showing the relation of the professional work of the Department to the public at large and by opening up viewpoints of the biological relationships to society.

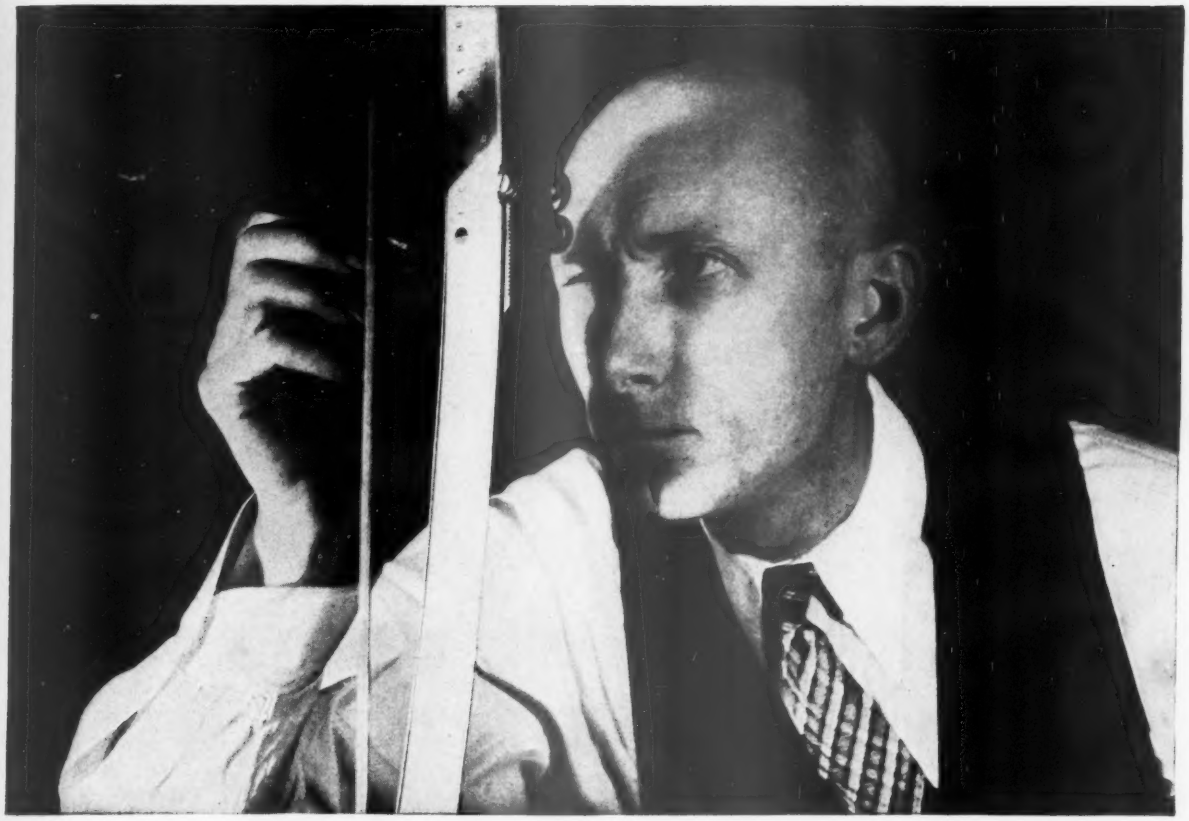
At the conclusion of the general discussion the work of the three options was referred to those members of the Committee best prepared by their business activities to comment on the work in each special field. Dr. Vaughan particularly commended Option 1 as providing a broad training for men who might enter the field of public health administration or the study of medicine. He stated that the men who had gone from this Course to the Detroit Department of Health [of which he is commissioner] had been well trained and fitted quickly and effectively into the organization, carrying out the work assigned to them with intelligence, coöperation, and zeal.

Mr. Waters expressed his satisfaction with the training in the field of food technology and industrial biology. He also spoke from personal knowledge since men from this option had entered the employ of General Foods Corporation and had successfully met the requirements imposed upon them.

Mr. Eddy commented specially on Option 3 and expressed the opinion that this breadth of training gave to the men viewpoints and knowledge which they would find directly applicable in state or Federal work as public health engineers. These broad conceptions of the biological aspects of sanitary problems are of the type desired in the partners in the organization which he represents, although the tendency was, for the most part, to take men of civil engineering training or mechanical engineering training for the new assistants coming to their staff directly from the Institute or from other technical schools.

Attention was directed to the various trends of thought, as recently expressed in professional groups, in regard to the most effective preparation for administrative work in public health. Extended discussion led to the conclusion that personality, capacity, and soundness of fundamental training in public health and science are the essentials, rather than the possession of a particular type of degree.

It is certainly clear that from the rise of sanitary science, more than 40 years ago, to the present time, the influence of this Department in public health in America has been a large and effective one. The Committee believes it will continue to occupy a leading place so long as the traditional standards of training are maintained. The programs of study at the Massachusetts Institute of Technology are unique and have been worked out with great care, after much discussion with leaders in actual administrative practice and with close attention to the trends of public health affairs and industrial life. The Committee therefore seemed unanimous in the assumption that (*Concluded on page 126*)



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INSTITUTE GAZETTE

(Concluded from page 124)

the courses as now arranged provide adequate fundamentals for work in the fields which the men in the respective options might look forward to as life careers.

The graduate courses offered are closely coördinated with the research activities of the Department. In the consideration of the graduate courses Dr. John W. M. Bunker, Chairman of the Departmental Committee on Graduate Work, described clearly the fundamental, critical, and exact researches which are now under way under his direction and under the direction of the various staff members. It was brought out that the graduate studies are designed not merely to broaden the student's fundamental, factual knowledge, or to call his attention to specialized fields of application, but to develop his critical faculties and his judgment and appreciation of exact measurement. The Committee was impressed with the splendid progress of research work conducted by Dr. Bunker and his associates and was definite in its belief that this research must be continued.

The Committee appreciated the splendid work which has been done by Professor Clair E. Turner, '17, in developing public health education. This has brought great credit to the Institute and has been not only national but international in its scope. He has returned from a leave of absence devoted to lecturing and studying health education conditions in Europe, India, the Philippines, East Indies, China, and Japan. In the Asiatic countries, persons trained in the Department are in charge of health education programs, and the influence of the Department has been particularly noteworthy in this field of endeavor.

The discussion with reference to the number of graduate students who could be properly trained in the Department elicited the fact that a careful survey recently made indicated that with the present staff, space, and equipment, about 12 graduate students working for the master's degree or the Ph.D. degree could be properly cared for. The number at the present time is 11. With more ample space and some increase in equipment but the same staff, about 20 would be the limit which could be well handled by the Department, but with enlargement of the staff this number could be considerably increased. At the present time practically all those receiving degrees are located without serious delay in good professional positions. Under normal conditions more men could be placed than are available. In addition to the above graduate students, it is possible to prepare adequately at least six students for the Certificate in Public Health.

Attention was directed to the great service which has been rendered by the Rockefeller Fund in aid of research. The need for more space for the development of the Department was stressed. The present teaching and research laboratories are working to capacity.

The pressing needs of the Department, therefore, seem to be: a continuation of research funds, and, as soon as possible, increased space and enlargement of the staff in order to take care of what seem unquestionably to be the normal opportunities for growth.

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TECHNICS AND THE WOMAN

(*Continued from page 115*)

off in the immediate, tangible, practical sense, as a result of the scientific application of ingenuity and inventiveness, even though room for improvement is, in her eyes at least, vast.

But man often fails to remember that there is another and far more important phase of the question. To return for a moment to our electric dishwashing machine: To many women, the actual washing of dishes is fundamentally pleasant; the suds, the warm water, the manual occupation all contributing toward the establishment of a contemplative mood, a surcease from pressure and frenzy. The machine takes away from her not the worst of the drudgery, but this, the most important part of the operation philosophically. In doing so, it symbolizes rather well the basic effect which science has had upon her.

The contemplative frame of mind is more necessary to woman than is anything else — far more necessary to woman than it is to man — because the potentiality of motherhood is the cause and the result for which woman exists and has her being; and the essence of motherhood is contemplative. Whether she has children or not, woman must be a mother; she must make some corner into home, a focus of calm and poise, where security and stability rule, where contemplation is ordered. This state is the core of being a woman. Around it always there have been fringes of odd jobs — housework, dairy work, farm work — reserved to woman, varying in detail with the centuries.

The emancipation of woman, as man has seen it, has been to free her from the drudgery of her odd jobs, generally by substituting a new way of doing the odd job. The new ways which science has supplied are easier than the older ones, but they are only substitutes. For many women, they have led to a complete departure from the routine of home, dairy, or farm, to the substitution of an adding machine for a washboard, to jumping when the buzzer sounds to call her to some kind of ancillary task which depends upon the male boss's need or whim. In this aspect, the use of science for her emancipation has been to her little more than a restatement in new terminology of what man considered the old dependence and inconsequence. Moreover, it has put her into callings for which she was not meant, often with serious results in psychological maladjustment and spiritual unhappiness. It is an interference with the natural order of things and as such enjoins penalties.

Science thus has gone further than the fringes of woman's world and has trespassed upon the central core of independence which has hitherto always been hers, even though man could not understand it and did not recognize it. It is tending to take from her the self-contained, creative calling which is hers by right. The deferred marriage, the flitting of the wage earner from job to job, the economic uncertainty produced by booms, depressions, and technological unemployment enforced by centralization and industrialization — all of these combine to make her question science.

(*Concluded on page 130*)

Technology Men . . .

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Some of the features of the January, 1937, issue are listed at the right.

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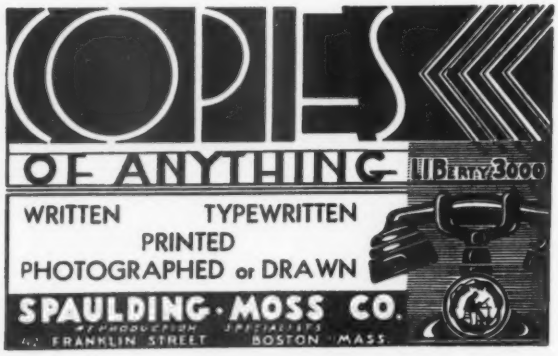

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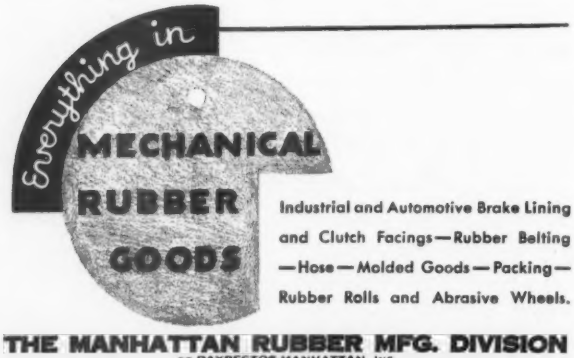
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TECHNICS AND THE WOMAN

(Concluded from page 128)

It is not that woman objects to scientific advancement; it is rather that she objects to scientific meddling with the natural order. Woman is at heart a peasant. She would rather have the feel of earth in her hands than the sight of orchids on black velvet, for she must have direct contact with the actual, with as near to ultimate reality as is possible. A mechanical contrivance which will save her carrying buckets of water from a well is not a substitute for a reality, but when science substitutes the electric fan on the living room table for the shade of the maple tree on the front lawn and so orders the conditions of living that urbanization makes the substitution inescapable, then woman is at war with science. When science devises a machine which will carry people from the Atlantic to the Pacific Coast in four days, woman may marvel at the cleverness of the machine, but she is more likely to wonder at the idea. Wherein lies the virtue that so much distance can be covered in so short a time? Is the world any the better place in which to live or into which to bring children? Does the achievement make for wisdom? for kindliness? for contentment and stability?

The essence of life, then, is made up of abstract qualities which cannot be poured into or out of a test tube, abstract qualities which, as woman sees them, demand security for survival. The maintenance of them has been her main task since men began to walk upright. To obliterate them is, in her eyes, to obliterate the justification of existence itself. Therefore she argues that science should first work out a philosophic justification for its inventions and the changes it imposes; if the inventions and the changes follow on such justification, they will probably be sound. Speed and change in themselves are not philosophic justification for anything. They are the cause of instability, unrest, insecurity. And as science is directly or indirectly responsible for these things, woman must condemn it. She has adapted herself to some extent to the scientific age, to her emancipation without representation, for adapt she must if she is to survive as woman. Compromise she cannot, in spite of any evidence to the contrary in Russia at present; there can be no compromise, fundamentally, with childbirth and with what childbirth brings in its train. That is the philosophic position engendered in her by nature. So long as the natural order is not too far thrown out of gear by artificialities, woman will survive, but when civilization sets too great a handicap on early marriages, on family life, on the contemplative attitude, then science will have to go along with Julian Huxley and decant its babies, for woman will have been successfully nullified.

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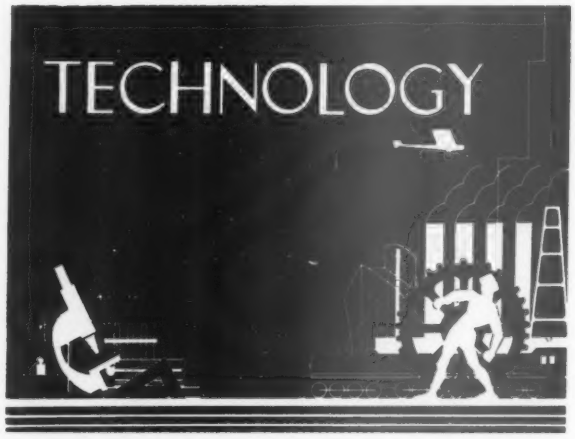

PROSPECTS FOR 1937

With only a limited number of graduates still available for employment from the classes of 1935 and 1936, and an increasing demand from industry, the employment prospects for the class of 1937 are more encouraging than for any recent class. During the period from January to July 1936, approximately two hundred personnel representatives of the larger companies visited the Institute in search of new personnel for their organizations. Many of these companies have already sent their representatives to the Institute this year.

On account of the anticipated large demand for 1937 graduates, employers are urged to inform the Placement Bureau of their probable personnel requirements as early as practicable.

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